THE

MODERN PLUMBER

AND SANITARY ENGINEER

PLUMBING OFFICIALS AND EDUCATIONISTS

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THE MODERN PLUMBER AND SANITARY ENGINEER

TREATING OF PLUMBING, SANITARY WORK, VENTILATION, HEATING (ELECTRIC AND OTHER), HOT-WATER SERVICES, GAS-FITTING, ELECTRIC LIGHTING, BELL-WORK, GLAZING, &c.

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UNDER THE EDITORSHIP OF

G. LISTER SUTCLIFFE

A.R.I.B.A., M.R.S.I.

Editor of "The Principles and Practice of Modern House Construction", &c.

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THE EDITOR

SECTION I.—INTRODUCTORY

CHAPTER I

THE PLUMBER

So many words have been spoken and written in disparagement of the plumber and his work, and the harsh statements have been repeated so glibly, that the man in the street is inclined to think that the skilful and conscientious plumber is as rare in modern England as was the black swan in ancient Rome. Such an opinion is as unjust as the kindred views that

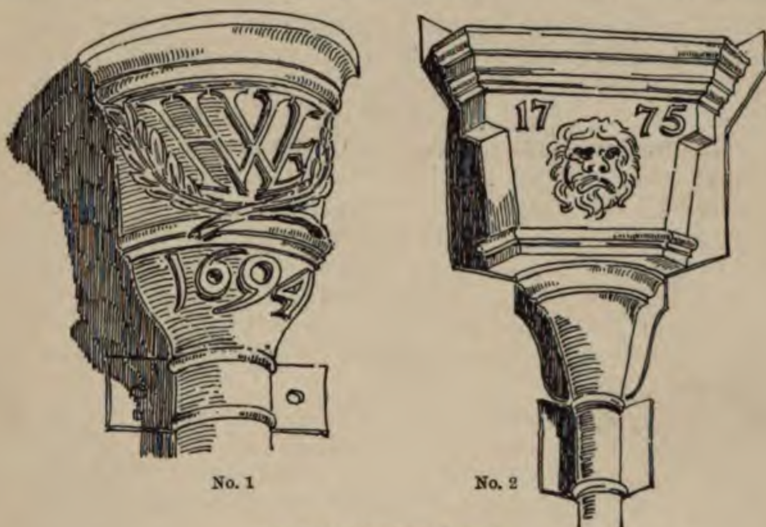

Fig. 1.—Lead Rainwater Heads

No. 1, Victoria and Albert Museum, South Kensington; No. 2, Lincoln's Inn, London.

all doctors are atheists, all theologians hypocrites, and all lawyers liars. The fact is that in every class and calling there are good men and bad, and many who are neither the one nor the other; but it has become a tradition that certain classes are fit subjects for cheap wit and abuse, and between jest and earnest the tradition survives long after its injustice and inaccuracy have been exposed.

The plumber's is an honourable and historical craft. Examples of lead-covered roofs, lead rain-water pipes and heads (fig. 1), gargoyles, and finials,

which have weathered the storms and the sun for hundreds of years, are still to be seen in our old cathedrals, castles, and country-houses; but the good reputation gained during these centuries was in some measure lost in the plumber's attempt to cope with the nineteenth century's demand for household conveniences. Water-closets of a primitive and insanitary type were invented and put into his hands, and he was instructed to fix them in odd corners of old houses, and to connect them to brick and rubble drains which had been laid, unknown years before, under the floors to leaky and unventilated cess-pools. The inevitable nuisance was laid at the door of the plumber, although he had not made the water-closet, or built the house, or laid the drains, or insisted on the work being done as cheaply as possible. He was merely one link in the chain of causes, but was made the scapegoat on whose shoulders was placed the blame for many errors besides his own.

It was unfortunate for the plumber that the demand for sanitary fittings arose before he, or indeed anyone else, knew on what conditions only the demand could safely be satisfied. That he was not alone in his ignorance, everyone acquainted with the subject must admit. Doctors, architects, engineers, inventors, builders, and property-owners were all groping in the dark, and learning slowly in the expensive school of experience. The plumber also has been learning, and the new generation which has grown up numbers in its ranks many who are fully qualified to carry out the most intricate work, and others who, with an intimate knowledge of the practical details of their craft, combine an adequate acquaintance with the general principles governing the design—as distinguished from the execution—of a system of plumbing.

Much of the credit for this improvement is due to those members of public and private bodies who have been instrumental in founding classes in which, for a small fee, the plumber is able to supplement the training obtained in the workshop. The Polytechnic Institutions and the Municipal Technical Schools up and down the country, and the City and Guilds of London Institute have done excellent work, but the facilities which they have provided would have been useless if the plumber himself had not been willing to learn.

The first polytechnic in London was established by the late Mr. Quintin Hogg, in 1872, and still continues its useful courses of instruction in Regent Street. Of even greater utility is the Institute founded by the City and Guilds of London in 1878, and supported by grants from the Corporation and Livery Companies of London. "The operations of the Institute are divided broadly into four branches:—(1) The City and Guilds Central Technical College [Exhibition Road, London, S.W.]; (2) The City and Guilds Technical College, Finsbury; (3) The City and Guilds South London Technical Art School; and (4) the Department of Technology of the Institute." The most important of these is the Department of Technology, as its operations are not restricted to London. Its object is "the registration and inspection of classes in Technology, Domestic Economy, and in Manual Training, and the holding of annual examinations in the subjects taught in such classes throughout the country and in the Colonies". Under the able guidance of the superintendent, Sir Philip Magnus, the department

PLATE I

No. 1. SICILIAN (ITALY)

No. 2. ST. ANN'S (BELGIUM)

No. 3. JAUNE LAMARTINE (FRANCE)

No. 4. ROUGE ROYAL (BELGIUM)

No. 5. ROUGE ROYAL (BELGIUM)

MARBLES IN COMMON USE

has grown, and the programme now includes upwards of seventy subjects, among which are plumbers' work and other branches of the building trade. In the "List of Persons registered as Qualified Teachers in Technology", about 150 names are given by the Institute under the heading "Plumbers' Work", and of these one-half are actually engaged in the work of teaching the subject in various parts of the country. This fact is evidence of the desire of plumbers both to teach and to learn.

It was not, however, until 1883 that much progress was possible even in London. In that year the City of London Parochial Charities Act was passed, and provided funds for the establishment of polytechnics in various parts of the metropolis; but it was not until 1889 that County Councils throughout the country were, by the passing of the Technical Instruction Act, enabled to levy a rate (and this of only one penny in the £) for technical education. In the following year certain Customs and Excise receipts were diverted from the national exchequer for the same purpose. By the Education Acts of 1902 and 1903 (for the country and London respectively) a more comprehensive scheme of secondary education was rendered possible. Education Committees with wider powers were established, and the limit of expenditure was withdrawn in county boroughs and increased from one penny to twopence in the £ in counties.

As a result of these Acts of Parliament, additional facilities have been and are being provided for the technical education of plumbers and others. The London County Council is alive to its responsibility, and already maintains more than a dozen technical institutes of various kinds, and assists by grants nearly as many polytechnics within its boundaries. Manchester also has an excellent Municipal School of Technology; and Technical Colleges are at work in Bradford, Brighton, Bristol, Derby, Glasgow, Huddersfield, Northampton, and other towns. Rapid progress will probably be made, but many years will pass before every artisan has the opportunity of attending a course of instruction in his particular trade. If, having the opportunity, he fail to take advantage of it, the fault will be his own, and blame will rightly rest upon him for any avoidable defect in the quality of his work.

In the meantime the plumber may point with some measure of pride to the progress which has been made under many difficulties. Every architect knows that the standard of workmanship has been raised during recent years, particularly in large towns. The plumber trained on modern lines takes a pride in his work, and, instead of wishing to bury his pipes in plaster or hide them under floors, is gratified by the opportunity of leaving them exposed so that every eye may see them. This is a great step in advance, and the new spirit is spreading. It is true that many plumbers have not yet come under its influence, but the provision of facilities for study will reduce the number of these year by year. Human nature being what it is, there will always remain a residuum of careless and [illegible] in every trade; but Nature has her own shrewd way [illegible] to her strict discipline we may leave them.

By those who have the right spirit in them [illegible] will be heartily welcomed. The plumber is [illegible]

only; the materials of his trade are lead, iron, brass, copper, pottery, and scores of others. He is no longer restricted to roof-work and simple water-services, but covers the wide field of sanitary plumbing, and exercises his skill in gas-fitting, heating-apparatus, bell-work, and other branches of the building trade. New inventions are constantly being brought to his notice, and new demands made on his services. Knowledge and intelligence are more than ever necessary, in addition to manual skill, and the training in the workshop and on buildings must be supplemented by classes and books.

The general use of water-closets and other sanitary fittings has thrown upon the plumber a great responsibility. Carelessness and ignorance displayed in the selection and fitting-up of these appliances may have serious consequences. The danger of inhaling air contaminated by emanations from drains and sewers may have been exaggerated, but it is nevertheless a real danger, and much sickness and loss of life might have been avoided if it had been kept in mind.

Bad plumbing is undoubtedly a menace to the health of the community, and this fact is the strongest argument in favour of the compulsory registration of plumbers. Bills to enforce this registration have been repeatedly introduced in the House of Commons, and although they have not yet been passed, they show that there is a strong body of public opinion in favour of the change. Opinions differ as to the wisdom or necessity of the measure, but there can be little doubt that, if it ever becomes law, it will raise the status of plumbers and foster the plumber's pride in his work, and these will be no mean advantages.

CHAPTER II

METALS

The chemist divides matter into two classes—*elements* and *compounds*. In an element all the molecules, or minute particles, are composed of similar atoms, while in a compound the atoms constituting the molecule are dissimilar.

A compound is not a simple mechanical mixture of two dissimilar elements, but results from an intimate chemical union of the atoms of these elements. Thus, atmospheric air is a mechanical mixture of the two elements, oxygen and nitrogen, each molecule being composed either wholly of oxygen or wholly of nitrogen; but water is a chemical compound, each molecule consisting of two atoms of hydrogen and one of oxygen.

In chemistry the atom of each element is known by a letter or symbol; thus an atom of hydrogen is indicated by the letter H, and one of oxygen by O, while a molecule of water, which consists of two atoms of the former and one of the latter, is succinctly expressed by the formula H_2O.

The metals most commonly used by the plumber are lead, iron, copper, tin, and zinc. Other metals, such as nickel, silver, and aluminium, are also used, but to a much smaller extent. In their pure state all these are

elements, but in their commercial forms small quantities of foreign substances are almost invariably present; thus, the lead of commerce usually contains a little silver, and we shall see that the special characteristics of cast- and wrought-iron and of steel are due in a great measure to the varying proportions of carbon, &c., which they contain. For the present, however, these metals may be regarded as elements.

But each of these elements is capable of combining chemically with certain other elements. The rust which forms on the surface of iron in the presence of air and moisture is due to the chemical union of the iron with the free oxygen in the air and with the hydrogen and oxygen of which the moisture is composed; the compound is known as "hydrated ferric oxide" or "ferric hydroxide". The litharge of the painter is a compound (lead monoxide), each molecule consisting of one atom of lead and one of oxygen, and "white-lead" is a more complex compound of lead, carbon, oxygen, and hydrogen.

When two or more metals are fused together, a certain amount of chemical union does in all probability take place, but the union is far from complete, and such mixtures are known, not as compounds, but as *alloys*. Solder and pewter are alloys containing various proportions of tin and lead; brass is an alloy of copper and zinc; and gun-metal, or bronze, an alloy of copper and tin.

If mercury is alloyed with any other metal, the mixture is termed an *amalgam*; thus, the "silvering" of mirrors is an amalgam of mercury and tin.

The principal alloys used by the plumber will be described in a separate chapter. Our first concern is with the metallic elements and compounds, and among these the first place must be given to lead.

1. *LEAD*

Chemical symbol, *Pb*, from Latin *Plumbum*, whence also the name "Plumber".
Atomic weight, 206·39.
Specific gravity, from 11·35 in the ingot to 11·37 when rolled or drawn.
Melting-point, 622–633° F. (328–334° C.).
Weight per square foot 1 in. thick—*cast*, 59·04 lb.; *milled*, 59·13 lb.

Properties.—Lead is a soft but heavy metal, bluish-grey in colour, malleable, and easily cut. It has a bright metallic lustre when freshly cut or melted, but tarnishes on exposure to the air. The tarnishing is due to the action of acids and of the oxygen and carbonic acid gas (CO_2) in the air, but these agencies have much less effect on lead than on some other metals commonly used in building, such as iron and zinc. Dilute sulphuric and hydrochloric acids have little or no action on lead, and this metal is therefore often used in some kinds of chemical works. Concentrated hydrochloric acid, however, slowly converts it into lead chloride, and nitric acid rapidly dissolves it. Its tenacity is small, and it is consequently ill adapted for resisting tensile stresses.

It expands considerably when heated, and contracts when cooled; repeated expansion and contraction may cause distortion or fracture, as, for

example, in the sheet-lead of roofs exposed to the sun's rays, and in the drawn-lead of pipes conveying hot water. In flat roofs the successive changes of temperature may lead to the formation of ridges in the lead, and ultimately to cracks. In sloping roofs the lead may gradually creep down the roof, becoming distorted in its progress, and may even leave the ridge exposed; the explanation is that gravitation causes the lead to expand and contract chiefly in a downward direction, and although the downward movement at each change of temperature is imperceptible, it is distinctly noticeable in the course of time. Pipes conveying water of varying temperatures also suffer, and may become distorted, or may eventually crack; the same defects may occur in pipes exposed to the direct rays of the sun, such as external soil-pipes. These properties of the metal call for the exercise of care and knowledge in its use.

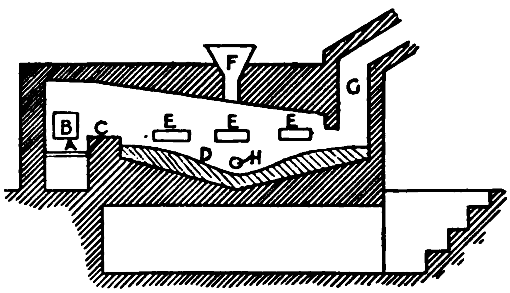

Fig. 2.—Reverberatory Furnace for Smelting Lead

A, fire-bars; B, furnace-door; C, bridge; D, hearth; E, work-doors; F, hopper; G, flue; H, outlet.

Manufacture.—Lead occurs in small quantities in the uncombined state, but the principal sources of supply are the ores known as *galena* and *cerussite*. The former, which is also known as *lead sulphide*, is a combination of lead and sulphur (PbS), while the latter is the carbonate of lead, composed of lead, carbon, and oxygen ($PbCO_3$). In addition to the elements mentioned, the ores usually contain varying proportions of other materials, including antimony, copper, tin, and silver.

The lead of commerce is principally obtained from galena, two processes being in use. In the first, known as the *reduction* process, the ore is roasted in a reverberatory furnace, a portion of the sulphide being thereby oxidized to sulphate and oxide; the temperature is then raised, when these react upon a further portion of the sulphide, with the formation of metallic lead and the evolution of sulphur dioxide. The reverberatory furnace commonly used is known as the *Flintshire furnace* (fig. 2), and has a depression or well in the hearth to receive the molten lead, which is drawn off through a tap-hole into a metal-pot. The slag is run off through an opening at a higher level. The hearth measures about 8 ft. by 6 ft.

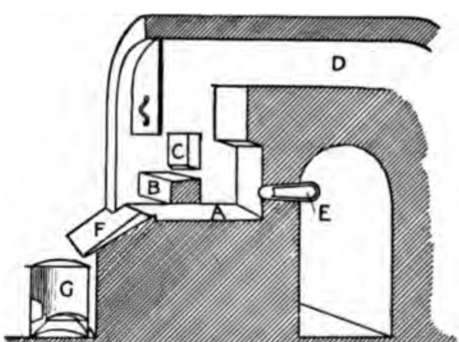

Fig. 3.—Sectional View of Scotch Hearth

A, hearth; B, fire-bar; C, door; D, flue; E, air-blast; F, work-stone; G, metal-pot.

For very pure ores the *ore hearth*, or *Scotch hearth* (fig. 3), is used;

in this a small blast of air is admitted to the back of the fire, and the molten lead escapes under the fire-bar and passes down a channel in the sloping "work-stone"—which is usually of iron—into an iron pot, which is heated by a small fire, so that the metal can be ladled out into moulds. In this system the lead fumes pass through a brick flue into condensing chambers.

In the second, or *precipitation* process, the smelting is carried out in a blast-furnace in the presence of metallic iron, the iron combining with the sulphur to form ferrous sulphide, which, with other metallic sulphides, produces a "matte" above the molten lead, while a fusible slag of silicate of iron rises to the top.

The lead obtained by either of these processes usually contains some proportion of other metals (copper, tin, &c.), which are removed by re-heating the metal in a shallow flat-bottomed reverberatory furnace, when most of the admixed metals collect upon the surface in the form of dross. This process is known as the *softening of lead.*

The silver present in the lead must, however, be removed by a further operation. If the lead is rich in silver, *cupellation* is adopted, the metal being heated in a reverberatory furnace in which the movable hearth consists of a dish of bone-ash, known as a *cupel*; a blast of air playing upon the surface of the metal is an important part of the operation. For lead containing smaller quantities of silver, the desilverizing may be effected by the *Pattinson* process, which is based on the fact that, "when argentiferous lead is melted and allowed to cool, the crystals which first form consist of lead which is nearly or quite pure". The argentiferous lead is melted in an iron pot, and, as it cools, the crystals when they form are ladled into another pot; the residue (one-third of the original quantity or less) is then emptied into a third pot on the opposite side. The first pot is again filled, and the operation repeated. As the successive pots are filled they are similarly treated, until at one end of the row there is an alloy rich in silver (which is afterwards cupellated), and at the other end nearly pure lead.

Market Forms.—As it leaves the furnaces the molten lead is poured into moulds to form what are known as *pigs of lead.* These weigh from 1 to $1\frac{1}{2}$ cwt. each, and are used in the manufacture of the more finished products, such as sheet-lead and pipes.

Sheet-lead may be either cast or milled. For roof-work cast sheet-lead is usually considered to be more durable than milled, and for this reason the Incorporated Church Building Society specifies that in all churches for the erection of which grants are obtained from the society, the former only must be used. Such sheets are often cast in the plumber's workshop from a mixture of pig-lead and old lead-scrap; the method of casting will be explained in Section II.

Nos. 1 and 2, Plate II, which have been reproduced from photographs taken at the Island Lead Mills, Limehouse, London, E., by the kind permission of the Island Lead Mills, Ltd., show the operations involved in the manufacture of milled lead. Pigs of lead are hoisted by means o crane and placed in the circular furnace-pan shown in No. 1, where

are melted. The molten lead is then run into a square casting-bed behind the pan, to form a slab about 9 ft. by 7 ft. and 5 in. thick. The slab is then moved along a bench, the top of which consists of a series of rollers, to the rolling-mill shown in No. 2. Here it is passed to and fro between heavy rollers, until it has been rolled out into a long sheet about 1 in. thick. This is cut across into various lengths, according to the size and thickness of the finished sheet required. Each piece is then separately passed to and fro between the rollers until it has been rolled out into a sheet of the required length and thickness. The ends and edges are trimmed, and the sheet is

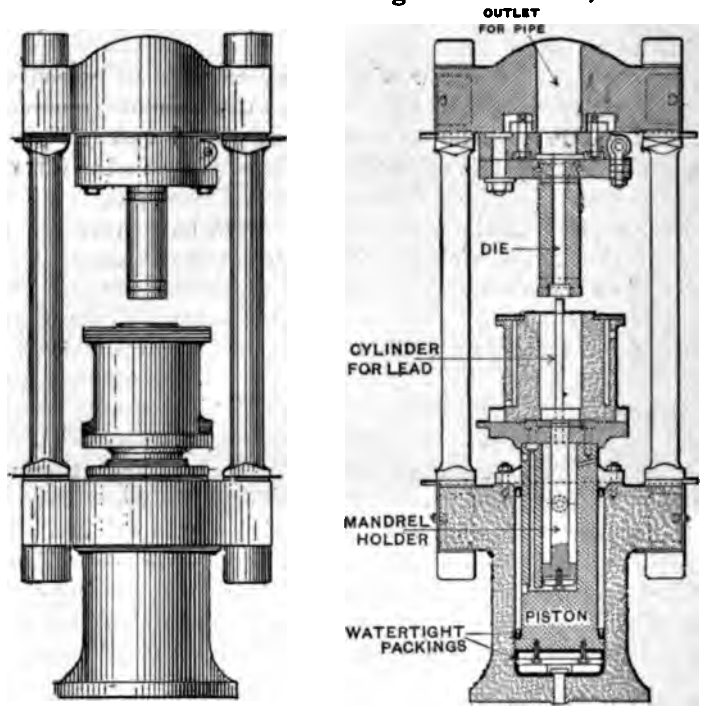

Fig. 4.—John Wilson & Son's Lead-pipe Press

finally rolled up and secured with cord; two rolls are shown on the trolley in No. 1.

Milled lead is described by its weight per square foot, three-pound lead weighing 3 lb. per square foot, and so on. The weights range from 3 to 14 lb. per square foot; heavier sheets are often known as *plates*. Sheets of milled lead are from 20 to 40 ft. in length, and from 6 ft. 9 in. to 9 ft. wide.

Pipes may be made from sheet-lead (with soldered seams) or cast from pig-lead, and these processes are still sometimes adopted for special purposes. Nearly all lead pipes, however, are now made by forcing molten lead through dies. Two forms of machine are in use. In each case there is a chamber for the molten lead, and at the top of this there is a circular opening equal in diameter to the external diameter of the pipe to be made, and through the centre of this opening a "core" passes equal in diameter to the bore of the pipe. In No. 1, however, the piston, which is usually

No. 1.

No. 2.

THE MANUFACTURE OF MILLED LEAD

operated by hydraulic pressure, is forced upwards, and the core is attached to it. With this arrangement the core is apt to bend, the result being that the metal is not of equal thickness throughout the circumference of the pipe. To prevent the bending, a bridge-piece is sometimes fixed across the chamber, the core passing through a hole in the bridge. This device secures a more uniform thickness of metal, but unfortunately the lead, after passing the bridge, does not always fuse together again in a perfect manner, and what may be termed "secret seams" are formed, which are a source of weakness in the pipe. In No. 2 the core is fixed to the bottom of the cylinder, and the piston itself, which works downwards, contains the orifice through which the lead is forced.

In No. 1, Plate III, the process of manufacturing lead pipe is shown. The apparatus consists of two furnaces, a hydraulic press, and a double drum on which the pipe is coiled. The lead is melted in one of the furnaces and is run into a strong cylinder, in the bottom of which a central rod or mandrel, equal in diameter to the bore of the pipe required, is firmly secured. The cylinder is then fixed in the press in such a position that the core passes through the centre of a hole or die equal in diameter to the external diameter of the pipe required. When pressure is applied, the lead is forced upwards through the annular space formed by the die and core, and issues in the shape of a pipe. The illustration shows a pipe of small bore issuing from the press and passing over a pulley to the double drum, on which it is wound. The axis of the drums rests on a central standard, so that the drums can be rotated in a horizontal plane. One man attends to the winding of the pipe and cuts it to the required length, and then gives a half-rotation to the drums, thus bringing the empty drum into position, and passing the drum with the coil of pipe to his mate, who ties up the coil and removes it.

Fig. 5.—"Slug" of Lead and Tin (No. 1); for the Manufacture of Tin-lined Lead Pipe (No. 2)

Larger pipes, such as soil-pipes and rain-water pipes, are not wound around drums, but are kept as straight as possible. A pulley is fixed at the necessary height above the hydraulic press, and a strong cord is passed over it. One end of the cord is attached to the end of the pipe, and the other end is held by a man whose duty it is to keep the cord taut as the pipe issues from the press. Round and rectangular pipes made in this way are shown in No. 1, Plate IV.

For the manufacture of lead-encased tin pipe the same apparatus is used, but the cylinder or "slug" (fig. 5, No. 1) consists of the two metals and is cast at two operations. The lead is first cast, a temporary core being placed in the mould so that the lead takes the shape of a short pipe with thick walls. The core is afterwards removed, and a smaller core, equal in diameter to the bore of the pipe required, is inserted, and the space between this core and the lead "slug" is filled with molten tin. The proportion between the two metals varies according to the quality of pipe to be made. When the

composite slug is subjected to hydraulic pressure, the two metals issue together in the form of a lead pipe with a lining of tin, thoroughly adherent and of uniform thickness, as shown in fig. 5, No. 2.

No 2, Plate III, shows the manufacture of "composition" piping of small bore. The apparatus is similar to that described above, but a larger drum is used, and before it reaches the drum the tube passes through a cup containing molten tin and thus receives an external "wash" or coating of this metal. Lead pipes are sometimes washed internally with tin in a somewhat similar way.

Cast-lead is used for traps, large bends, plain and ornamental ears for pipes of various kinds, rain-water heads, and other purposes.

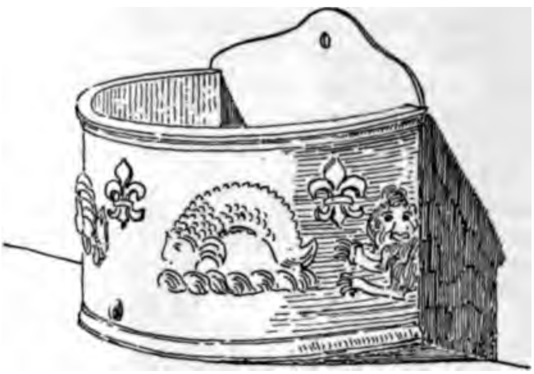

Fig. 6.—Old Cast-lead Cistern (Victoria and Albert Museum, South Kensington)

Alloys.—Pewter and solder are alloys of lead and tin, and lead is also present in some of the cheap brass-work; these will be described in Chapter III.

Compounds containing Lead.—Lead combines chemically with oxygen and other elements to form various compounds, some of which are extensively used by the plumber and painter. Among these the most important are litharge, red-lead, and white-lead.

Litharge is lead monoxide (PbO) in a solid crystalline state, and is obtained by the melting and subsequent solidifying of the yellowish powder known as "massicot", which is of the same chemical composition. Massicot is produced in the final process of desilverizing lead. The argentiferous lead is melted on a cupel of bone-ash in a reverberatory furnace, and exposed to a current of air, the oxygen of which unites with the lead to form massicot. Litharge is used as a "drier" in paints, oils, &c., and in the manufacture of flint-glass, earthenware glazes, &c.

Red-lead is the red oxide of lead, known also as "minium", and chemically as "triplumbic tetroxide" (Pb_3O_4). Commercial red-lead is a red or scarlet crystalline powder, and is prepared by heating massicot (lead monoxide, PbO) in iron trays in an oven, in contact with air, from which oxygen is absorbed. *Orange lead* is a pure variety of red-lead, obtained in a similar manner from white-lead (lead carbonate, $PbCO_3$) instead of massicot. Red-lead is used as a pigment in painting, and also as a cementing material for making water-tight joints in iron pipes, gutters, &c.

White-lead is a basic carbonate of lead ($2\,PbCO_3$, $Pb(HO)_2$). It is manufactured in various ways. The oldest process, known as the *Dutch*, is said to give the best results. Metallic lead is cast in the form of rough gratings or perforated slabs in order to expose a large surface, and these are laid one above the other in earthenware pots, which are shaped in such

No. 1.

No. 2.

THE MANUFACTURE OF LEAD AN[illegible]OSITION PIPES

a manner that the [illegible] above the bottom. [illegible] these are placed on a [illegible] then covered with [illegible] receive the second tier [illegible] stack of pots is allowed [illegible] gradually vaporized by the heat [illegible] bark. Carbonic acid [illegible] the two acids acting and [illegible] it into white-lead. [illegible] is now made in other ways. [illegible] are ground together in water [illegible] mixture the result being the formation of white-lead [illegible] salt and water. In *M*[illegible] acetate of ammonia and white-lead [illegible] acid, the acetate of ammonia being [illegible]

White-lead is a heavy white powder [illegible] largely used as a pigment by painters [illegible] water-tight joints in [illegible] with red-lead. The manufacture and the use [illegible] (see *Lead-poisoning*) [illegible] and covering-power has yet been [illegible] advantage of being blackened by sulphuretted hydrogen—a defect from which zinc oxide is free. White-lead is also mixed with putty and is used for many other purposes in building operations.

Lead-poisoning.—It is now a matter [illegible] soluble in certain waters used for [illegible] that persons habitually imbibe waters containing [illegible] quantities of lead in solution may suffer from lead-poisoning [illegible] The effect of a few doses is of course [illegible] to accumulate in the system [illegible] with the metal may be fraught with serious consequences. But even when no ill effects are obvious such water may have an injurious influence on persons subject to gout and some other diseases. [illegible] in the manufacture and application of white-lead, in the manufacture of pottery in which lead glazes are used, and in some other industries, suffer in a marked degree. Painter's colic is a well-known symptom of the disease; paralysis of some of the muscles of the forearm, and of the ball of the thumb, resulting in "wrist-drop," is another characteristic. In many cases the disease is fatal. A distinctive mark of lead-poisoning is a dark line along the gums close to the teeth caused by sulphide of lead.

Painters, and others engaged in the manufacture and use of materials containing lead, ought to pay the most scrupulous attention to cleanliness; meals ought not to be taken with dirty hands or in the workshops. Some authorities recommend the use of "lemonade or some other drink slightly acidulated with sulphuric acid" as a beverage, as the sulphuric acid combines with any lead which may be taken into the system to form the insoluble and inert sulphate of lead.

Waters containing more than about 7 parts of calcium carbonate per 100,000 do not dissolve lead to any appreciable amount, and it may therefore be said that nearly all "hard" waters may be passed through lead service-pipes without danger; the waters used in London are a case in point. Conversely, "soft" waters may as a rule be regarded as unsuitable for use in connection with lead pipes or cisterns, or even lead pump-barrels. Upland surface-waters, gathered from peaty moorlands, are probably the most dangerous, the organic acids derived from the gathering-grounds assisting the solvent action of the water. Such waters are now in some cases artificially treated with chalk or lime in order to neutralize the acids. Rain-water and other soft waters highly charged with oxygen, are also dangerous. Salts of magnesium also render water more susceptible to contamination in contact with lead.

Solvent water which has remained in contact with lead for the longest period is the most highly impregnated, and if, where lead pipes are used, there is any fear of a particular water being of this nature, a quantity equal to that contained in the pipes ought to be drawn off every morning before any supply is obtained for cooking or drinking. The water first drawn off may be used for other purposes.

It may be said in passing that lead dissolved in water can be removed by passing the water through an animal-charcoal filter, but unless the charcoal is frequently renewed the filter will be of little use, and may indeed prove to be a source of danger, as animal charcoal is not, as far as microbes are concerned, an ideal filtering medium, and long-continued use will convert it into a sort of microbic hot-bed.

The only safe course is to interdict the use of lead for the conveyance and storage of soft water, or to protect the lead from the solvent action of such water in some thoroughly effectual manner. Lead pipes washed with tin are a delusion and a snare, as the coating of tin is not invariably complete, and as it is always damaged when a joint is made. Lead pipes with a thin lining of tin are better, but here again there is great difficulty in making a perfect joint. In another invention an inner tube of tin and an outer tube of lead are used, with a packing of asbestos between the two; the metals are thus kept separate to allow for differences of expansion and contraction, and to facilitate the making of good joints. Some years ago a pipe was introduced with an internal coating of varnish or enamel, but the latter had so little adhesion that the invention had no real value.

Galvanized-iron tubes have been largely used, but in small-bore tubes the coat of zinc is sometimes incomplete, and in many cases the zinc is acted upon by the water, so that the iron is ultimately exposed. A more effective protection is obtained in the "Health" pipe, where an inner tube of tin is surrounded by an outer tube of wrought-iron; special fittings are made so that the tin lining is continuous at all joints and taps. For water-mains, 3 in. and upwards in diameter, cast-iron pipes coated with Angus Smith's solution, or protected by the Bower-Barff process, are generally used.

No. 1.

No. 2

LEAD PIPES (1), AND IRON FOUN

2. *IRON AND STEEL*

Chemical symbol *Fe* (from Latin, *Ferrum*).
Specific gravity, 7·84 to 8·14.

Pure iron is very rarely seen. The iron of commerce invariably contains other substances, among which may be mentioned carbon, sulphur, silicon, and phosphorus. These are found in different proportions in cast-iron, wrought-iron, and steel, the greatest proportion of impurities being in crude pig-iron.

Ores.—The principal ores from which the iron of commerce is obtained are magnetic iron ore, red hematite, brown hematite, and carbonate of iron (usually mixed with a large amount of clay, &c., and known as ironstone). The first ore contains about 70 per cent of iron, and the last from 40 to 20 per cent. There are large deposits of red hematite in North Lancashire and Cumberland, but great quantities are imported from the north of Spain; brown hematite is found in South Wales, the Forest of Dean, and other districts; and ironstone in the North Riding of Yorkshire, Staffordshire, Ayrshire, and other counties.

Pig-iron.—Iron ores (except hematite) are first calcined or roasted, and then smelted in a blast-furnace, coal or a mixture of coal and coke being used as fuel. With argillaceous ores lime is added as a flux. The lime combines with many of the impurities present in the ore, to form "slag", which floats on the top of the molten iron in the crucible at the bottom of the furnace. The slag runs out through a special orifice, and when the molten iron in the crucible rises to the level of this opening, the furnace is "tapped" by withdrawing a plug at the bottom of the crucible, and the molten metal flows out into a main channel (the "sow") with short side-branches (the "pigs"), formed in a bed of sand. Pigs of iron weigh about 1 cwt. each. Mixtures of ores of different kinds are often used, a calcareous ore, for example, being mixed with an argillaceous ore, the lime in the first serving as a flux for the second.

Cast-iron.—

Specific gravity, 7 to 7·6.
Weight per square foot, 1 in. thick, 36·4 to 39·5 lb.
Ultimate tenacity, 5 to 15 tons per square inch.
Ultimate resistance to compression, 38 to 58 tons per square inch.

Properties.—Cast-iron is a greyish-white metal, hard and brittle, with a granular or crystalline fracture. It varies greatly in strength, and as its resistance to tension is comparatively small, and always uncertain, it is now seldom used for girders and other structures where tensile stresses are to be resisted. The metal soon corrodes in moist air at ordinary temperatures, particularly in the presence of carbonic acid gas (CO_2), the red hydrated ferric oxide (known as "rust") being formed. Dilute hydrochloric, sulphuric, and nitric acids dissolve it, but concentrated nitric acid has no solvent action upon it. One of the most useful properties of cast-iron is its fusibility, which allows it to be cast in a molten state into intricate shapes.

Crude pig-iron contains 6 or 7 per cent of impurities, of which the most important is carbon. This may be either in combination with the iron, or uncombined, the latter being known as graphitic carbon. The total amount of carbon may range from 2 to 5 per cent. In "grey" pig-iron the bulk of the carbon is graphitic, and the iron is more fluid when melted, and softer when cold, than the "white" pig-iron, in which the carbon is nearly all combined. Seven or eight varieties of pig-iron are sometimes enumerated, the extreme "grey" being No. 1, and "white" at the other end of the series, while one or more of the intermediate varieties are known as "mottled". Grey pig-iron is especially suitable for fine and intricate castings, where great fluidity is required, while the white is most suitable for conversion into wrought-iron.

Uses.—The principal uses of cast-iron, as far as the plumber is concerned, are for water-mains, drain-pipes, soil-pipes, rain-water pipes, and gutters, and heating-apparatus pipes and boilers, but there is scarcely any branch of the plumber's work in which cast-iron is not required. It is used for pump-barrels, sanitary fittings (particularly baths and small flushing cisterns), wet gas-meters, large valves, inspection-chambers and covers, &c. For joists and girders it has now been superseded by steel.

Manufacture.—In making castings, the pig-iron is again melted in a blast-furnace, known as a "cupola", and is then poured into a mould of fine sand of the required shape (see Plates IV and V). A small portion of sand in contact with the molten metal is fused, and forms on the surface of the casting a hard skin, which ought to be retained where practicable. Before the sand-mould can be prepared, a "pattern" (usually of wood) is first made of the same shape as the casting required, but slightly larger to allow for the shrinkage of the metal in cooling, and from this the sand-mould is prepared.

For pipes the external shape is formed in a sand-box in two semicircular halves, which, when placed together, form a complete circle; a "core" is inserted to give the bore of the pipe. The core consists, as a rule, of a central rod or rods of iron, wrapped around with hay, and on this foundation moulders' sand in a moist condition is spread until the required diameter is obtained. The sand is carefully moulded and finished to a smooth surface, and then brushed over with plumbago or black-lead. If this core is not exactly concentric with the mould, the thickness of the metal will not be uniform. The old method of casting pipes in a horizontal position is now seldom adopted in the best foundries; more perfect castings are obtained by casting the pipes vertically or nearly so. Ordinary cast-iron pipes of all kinds ought to be true in line, of equal bore throughout, free from sand-flaws, pinholes, &c., and the metal ought to be of uniform thickness and to give a clear ringing sound when struck with a hammer. The flanges of pipes are cast on the pipes, and are afterwards turned in a lathe, so that true surfaces may be obtained. The spigots and sockets of water-mains and gas-mains are also turned and bored.

Malleable Iron.—The name "malleable iron" was at one time applied to what is now known as wrought-iron, but at the present day it is restricted to cast-iron which has been rendered less brittle by annealing. The process

No. 1.

No. 2.

THE MANUFACTURE OF CAST-IRON BATHS

consists in covering the castings with powdered hematite ore and subjecting them to heat for some days; the temperature and duration of the heat vary according to the degree of malleability required. Some of the impurities in the iron are removed by annealing, so that the composition and properties of the metal become more like those of wrought-iron. The process is applied to castings of small size only, such as brackets, gate-hinges, latches, iron-tube fittings, &c.

Wrought-iron.—

Specific gravity, 7·25 to 7·79.
Weight per square foot, 1 in. thick, 37·7 to 40·5 lb.
Ultimate resistance to tension, about 25 tons per square inch.
Ultimate resistance to compression, about 30 tons per square inch.

Properties.—Wrought-iron is less fusible than cast-iron, and cannot be cast. It is much more tenacious, and when heated can be hammered and rolled into various shapes, and can be easily welded. It is a better conductor of heat, and is therefore often preferred for heating-apparatus pipes. It is, however, more rapidly corroded by ordinary atmospheric influences. It is the purest form of ordinary commercial iron, the impurities being in some cases less than $\frac{1}{2}$ per cent, and the carbon being from ·06 to ·15 per cent.

Manufacture.—The process of converting cast-iron into wrought-iron is known as *puddling*. The "white" cast-iron, or the variety known as "grey forge" is the most suitable for the purpose; if "grey" iron is used, it is often converted into white in a refining furnace before being "puddled". The puddling furnace is of the reverberatory type, and is usually constructed of fire-bricks bound together by iron plates and bolts, but rotary puddling-furnaces are also used. The ordinary furnace has two compartments, the "fire-box", or furnace proper, and the "bed", which are separated by a "bridge" of fire-bricks, carried up to about half the height of the furnace. The products of combustion from the furnace pass over the "bed" to the flue beyond. The bed is plastered or "fettled" before each charge with a composition—consisting usually of ground oxide of iron (hematite) and water—which plays an important part in the process of purification. Lumps of iron are thrown into the bed through a door in the side, until the full charge of about 4 cwt. has been inserted. The fire is then made up, and the flames pass over the bridge and "reverberate" from the arched roof on to the iron, which is repeatedly turned over with a rod until the melting is complete. A heavier bar, bent at the end, is then used to stir the molten metal to and fro; carbonic oxide is expelled in flashes of blue flame, and the mass appears to boil. As pure iron has a higher melting-point than impure, the removal of the impurities from the molten metal causes the more purified portions to become less fluid, and ultimately these are worked into two or three lumps or "blooms", while the more liquid "cinder" is run off. The "blooms" are rapidly placed under a steam-hammer, which squeezes out some of the liquid slag contained in them, and welds the metal into a solid mass or "puddled bar"; more slag is squeezed out by passing the bars through a succession of shaped rollers. In the manufacture of plates the rolled bars are reheated and passed between straight rollers.

Uses.—Wrought-iron is used by the plumber in the form of pipes or tubes for conveying gas, water, and steam, cisterns of various kinds (usually galvanized), bath-boilers, heating-apparatus boilers, hot-water cylinders, plain and corrugated sheets, &c., and for a variety of smaller requisites, such as ordinary nails and pipe-nails.

Steel.—

Specific gravity, 7·6 to 7·8.
Weight per square foot 1 in. thick, 39·5 to 40·5 lb.

Steel consists of iron and other substances, namely, carbon, silicon, phosphorus, sulphur, and manganese. The proportion of iron is less than in wrought-iron, but more than in cast-iron. The carbon is present in a proportion intermediate between the proportions present in cast- and wrought-iron, but varies according to the nature of the steel. In mild steel it may be little more than ½ per cent, while in hard steel it may be 2 or 2½ per cent. Excess of carbon renders the steel brittle. Nickel and other metals are sometimes added to give additional hardness, as in the case of armour-plates, &c.

Steel is largely used for cutting-tools of all kinds, and the introduction of the *Bessemer process* of manufacture, by which the cost of production was greatly reduced, has allowed it to take the place of wrought-iron for constructional work, such as girders, stanchions, bridges, roofs, &c. In the Bessemer process an egg-shaped vessel, known as a *converter*, is used. It is made of iron, lined with a refractory material, and has an orifice at the top; the bottom is perforated with a number of small holes, through which a powerful blast of air can be forced by means of a "blower" or fan. The converter is mounted on trunnions, and after being heated is swung until the longitudinal axis is horizontal. Molten cast-iron is then run in nearly to the level of the lowest blast-holes; the air-blast is then started, and the converter is swung into a vertical position, so that the molten iron flows over the blast-holes, and the air is forced violently through it, thus oxidizing the carbon and some of the other impurities. The converter is again swung into a horizontal position, and the air-blast stopped; a calculated quantity of molten spiegel (a white cast-iron of known composition) is then added in order to give the required proportion of carbon to the whole mass. The spiegel mixes with the converted metal with a violent agitation, and the liquid steel is finally run off into moulds of suitable size.

In the *Siemens-Martin process* wrought-iron or Bessemer steel scrap is added gradually to a bath of molten cast-iron of high quality, and, when the whole is melted, spiegel is added to give the required proportion of carbon, &c.

Steel can be hardened by being made red-hot, and then being suddenly cooled by being plunged into cold water, or in some other way. The extreme hardness and brittleness thus obtained can be "tempered" by reheating the steel to various temperatures according to the degree of hardness required, and again cooling it.

Protection from Rust.—Cast-iron is often protected in some measure against rust by being painted with white-lead or other paint, but these are not suitable for every situation, and at the best require frequent renewal.

Cast-iron pipes are now usually protected by being steeped in a bituminous composition—known as *Angus Smith's solution*—which consists of pitch, coal-tar, resin, and linseed-oil. The pipes are thoroughly cleaned and heated to a temperature of about 700° F., and are steeped in a bath of the solution at a temperature of about 300° F. The black coating deposited on the pipes is smooth and fairly durable, but for external work, such as soil-pipes, painting is also required.

Less commonly pipes are treated by the *Bower-Barff process*, in which a protective film of the black or magnetic oxide of iron is formed on the surface by subjecting the pipes to the action of superheated steam.

Galvanizing is a more expensive method of protection, by which a thin coat of zinc is deposited on the metal. The zinc is easily affected by soft water and by acids, and the protection which it affords in this country is only temporary, particularly in the acid-laden air of towns.

The name "galvanized iron" is applied to iron (whether cast or wrought) which has been thus coated with zinc. The iron is thoroughly cleansed by being pickled in dilute hydrochloric acid and scrubbed with sand, and is then immersed for a short time in a bath containing molten zinc. Dry sal ammoniac (ammonium chloride, NH_4Cl) is first scattered over the molten zinc, and fuses on the surface, forming a layer which keeps the zinc clean, and also serving as a flux. A thin coating of the molten zinc adheres to the surface of the iron, and protects it from rust for a time. The zinc itself is, however, corroded by moist air containing traces of acids, and the protection is therefore only temporary.

Galvanized wrought-iron is largely used by the plumber in the form of water-pipes for domestic services and heating apparatus, water cisterns and tanks, hot-water cylinders, roofing-sheets (plain or corrugated), pipe-hooks, &c.; and galvanized cast-iron is used for rain-water pipes, soil-pipes, drain-pipes, small flushing-cisterns, manhole-covers, &c. In small tubes the coating of zinc is not always perfect throughout the length of the bore, and such tubes ought always to be carefully examined before being fixed. Cisterns, cylinders, and other vessels must be made from plain wrought-iron plates riveted together before being galvanized.

Japanning is the operation of coating iron, &c., with a hard coloured varnish by the aid of heat. It is used to protect the metal of cheap iron and zinc baths and other sanitary fittings, and although harder and more durable than ordinary paint, and less affected by hot water, it is inferior to metallic, vitreous, and porcelain enamels. The "japan" consists of amber or resin dissolved by heating with boiled linseed-oil, and mixed with other materials according to the colour desired. After the japan has been applied, the article is heated in an oven for some hours. For good work additional coatings are necessary, each coat being rubbed down with gro
and then with rotten-stone, &c., before the next is a
articles, such as baths, are often sold in three qualit
according to the materials used, the number of coat
"finish".

Metallic Enamel is a superior kind of japan,
ingredient. It is much used for cast-iron baths,

Enamelled Iron is iron to which a thin coating of glass or enamel has been applied by the aid of heat. Enamelled iron is now often used for cooking utensils, and (by the plumber) for baths, sinks, traps, soil-pipes, drain-pipes, &c. There are two principal varieties, known as *glass* or *vitreous enamel* and *porcelain enamel*, the latter being the more costly. The names are somewhat misleading, as glass is common to the two varieties. The porcelain enamel has, however, more "body" than the other, and a pure white surface can be obtained. Vitreous enamels vary considerably, some approximating to porcelain enamel (as in the case of modern "vitreous-enamelled" cast-iron baths), while those used for soil-pipes and drain-pipes are nearly pure glass. The enamel consists of silica and borax mixed with various substances, such as soda, alumina, and the oxides of lead, tin, &c. These are fused together, cooled, ground to a fine powder, and washed, and are applied to the well-cleansed surface of the metal. The article is then heated in a furnace until the enamel fuses.

One disadvantage of enamelled iron is that, when heated, the metal expands more than the enamel, and causes the latter to peel off. This defect is more commonly seen in pans and sinks than in baths. The enamel may also be damaged by a blow; the impact of a heavy waste-plug on the bottom of a bath, for example, may crack the enamel, and the edges of enamelled-iron sinks are often chipped by metal pails.

Ferric oxide (Fe_2O_3) is a compound of iron and oxygen, which is often used as a paint, particularly on iron-work.

3. *COPPER*

Chemical symbol, *Cu*, from Low Latin, *Cuprum*, which in turn was derived from the name of the island—Cyprus—from which the Romans obtained their chief supply of the metal.

Atomic weight, 63·18.

Specific gravity—*cast*, 8·8; *wrought*, 8·95.

Melting-point, 2000° F.

Weight per square foot 1 in. thick—*cast*, 45·7 lb.; *wrought*, 46·5 lb.

Tenacity	*cast*,	about 10 tons per square inch.
	wrought,	„ 15 „ „
	drawn into wire,	„ 25 „ „

Properties.—Copper is of a reddish-brown colour and of bright lustre, and takes a brilliant polish. It is extremely tough, and can therefore be hammered out into thin sheets and ornamental forms, and drawn into fine wire. Like iron, it can be either cast or wrought. It becomes brittle, however, when heated nearly to its melting-point. Dry air has little effect on it, but atmospheric air containing moisture and carbon dioxide (CO_2) induces the formation of a thin coating of the greenish carbonate of copper, as in the case of copper-covered roofs. It is moderately hard, but can be softened by heating to redness, and then cooled with water. As a conductor of electricity it is second only to silver, and is therefore largely employed for lightning-conductors, and for the cables and wires used for electric traction and lighting, electric bells, telegraphs, and telephones.

Nitric acid, either dilute or concentrated, readily attacks copper, but

dilute hydrochloric and sulphuric acids do not affect it except in the presence of air or in contact with platinum, and then only slowly.

Manufacture.—Copper is found in the native state in certain localities, but the great bulk of the world's supply is obtained from ores of various kinds, in which the pure copper ranges from about 8 to 90 per cent. The ores commonly used in this country contain sulphides, iron, &c., and the process of smelting involves six distinct stages, which may be briefly stated thus:—

1. Calcining the ore, usually in a reverberatory furnace.
2. Fusing the calcined ore, the result being a fused mass known as *coarse metal*, which is granulated by being allowed to flow into water.
3. Calcining the granulated coarse metal.
4. Fusing the calcined mass with slags rich in oxide of copper, &c., thus producing what is known as *fine metal* or *white metal*.
5. Roasting the white metal to produce *blister-copper*.

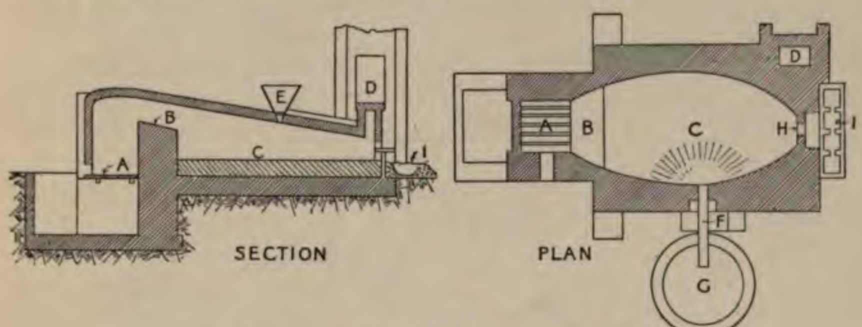

Fig. 7.—Reverberatory Furnace for Smelting Copper

A, fire-bars; B, bridge; C, hearth; D, flue; E, hopper; F, outlet for molten copper; G, granulating tank; H, outlet for slag; I, sand-beds for slag.

6. Refining the blister-copper by melting it in a reverberatory furnace in an oxidizing atmosphere, and afterwards throwing anthracite on the molten copper and stirring this with green-wood poles.

Uses.—Copper is extremely durable when subject only to ordinary atmospheric influences, and is therefore an excellent material for roof-coverings. It is a very good conductor of electricity, and is therefore almost universally employed for electric-light cables and electric-bell wires. It is also well adapted for the boilers and cylinders used in domestic hot-water apparatus, particularly where the water is "soft", and for baths, cooking-vessels, sinks, tubes, &c. Green salts of copper may be formed on the surface, and, as these are soluble in water and poisonous, a coating of tin is usually applied to copper cooking-vessels, and frequently to baths, sinks, &c., by dipping them into a bath of mol[illegible]in. Copper itself can also be deposited on other metals by m[illegible]pper nails are used by the plumber, slater, and ti[illegible] tiles, &c., and the metal is now freely used [illegible] door-handles, and other ornamental hardwa[illegible]

Copper tubes are also used by the [illegible]d

heating-apparatus pipes, and may be either "seamed" or "seamless". The old method of making seamless tubes of copper or brass is to cast a hollow shell in a similar manner to that adopted for cast-iron pipes, but as the internal and external surfaces are generally unsound, and the metal as a whole somewhat spongy, the shell is usually reheated and passed between rolls having suitable grooves, a plug or mandrel being first inserted in the shell, so that the metal is compressed between the mandrel and the rolls. Sometimes the shells are cast with thicker metal, and are then bored inside and turned outside to remove the irregularities and the unsound parts. Shells have also been made by stamping them in a hydraulic press out of a rolled and homogeneous plate. By a new and ingenious "piercing"

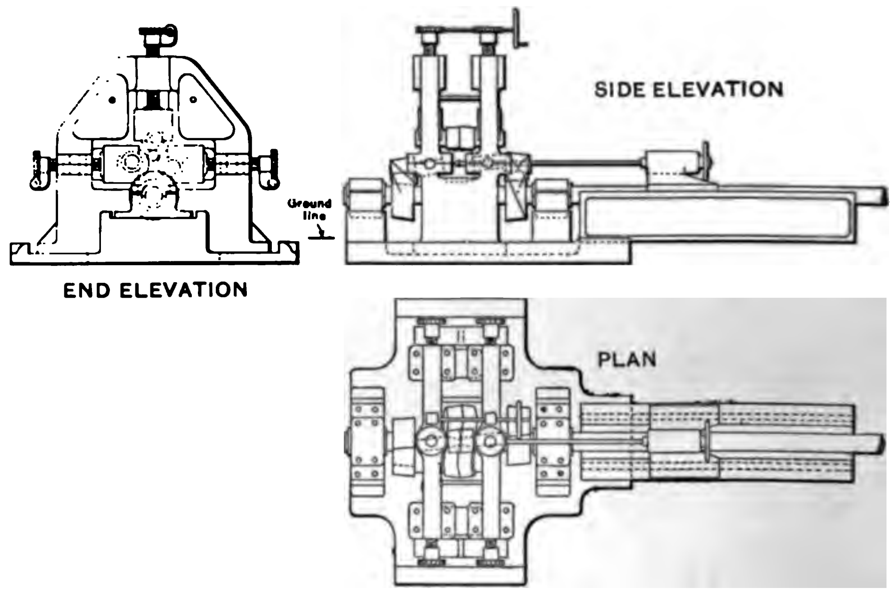

Fig. 8.—C. J. Dore's Piercing Machine for making Copper and Brass Tubes

machine (fig. 8), recently invented by Mr. C. J. Dore, copper shells are made from plain round rolled bars. The bar or billet is cut to a suitable length and passed in at one end of the machine, and is gripped by two cross-set horizontal rollers, which grip the billet and force it against a revolving mandrel: the mandrel pierces the billet, and forms a core, over which the metal is forced in the form of a hollow shell.

In whatever way the shells are made, the finishing process is generally the same. The hollow shell is drawn cold, on a "draw-bench", through suitable dies and over plugs or on mandrels, sufficient passes being made to obtain the required outside diameter and thickness of metal. The metal is rendered brittle by this drawing process, and the tube is generally annealed after each draw to bring it back to a ductile condition.

Brazed or seamed copper tubes are made from strips of rolled metal of the required length, width, and thickness. The strips are turned up on a draw-bench into a cylindrical shape by passing them through holes or dies,

tail-plugs being inserted to support the inside, and the edges are "scarfed" or bevelled so that the overlapping joint may not be too thick. The cylinders are wired to keep the overlapping edges in position, and the seam is cleaned with acid, and suitable solder is laid along it. The tube is then passed through a furnace, whence it emerges with the solder in a molten condition. As the tube cools, the seam is filed or "floated" to remove the rough parts, and the tube is taken again to the draw-bench, and drawn through finishing dies—with tail-plugs supporting the inside of the tube—which give the exact diameter required and also a smooth finish.

Alloys.—The alloys of copper are of great utility, the most important being:

Brass and *Muntz-metal*, which are alloys of copper and zinc;
Bronze, *Gun-metal*, and *Bell-metal*, alloys of copper and tin;
Phosphor-bronze, an alloy of copper and tin, containing a small proportion of phosphorus;
And *Aluminium-bronze*, an alloy of copper and aluminium.

It is also present in the alloys known as *German silver* and *Britannia metal*, and our gold and silver coins are really alloys of gold or silver with copper. The most important of these alloys will be described in the next chapter.

4. *TIN*

Chemical symbol, *Sn* (from Latin, *Stannum*).
Atomic weight, 118.
Specific gravity, 7·3.
Melting-point, 450° F.
Weight of 1 sq. ft., 1 in. thick, 37·9 lb.

Properties.—Tin is a white metal with a brilliant lustre, which is not easily tarnished by atmospheric agencies. It is harder than lead but softer than zinc, and can be beaten out into "tin-foil" or drawn into wire. Ordinary nitric acid dissolves it, and strong hydrochloric acid also affects it, but other acids have little or no action upon it at normal temperatures. Its melting-point (450° F.) is much lower than that of lead (633° F.).

Manufacture.—Tin is obtained from the ore known as *tinstone*. If the ore is impure, it is crushed and mechanically washed, and then calcined in either a reverberatory furnace or a revolving calciner. The calcined ore is pulverized and washed, mixed with powdered anthracite and a small quantity of lime or fluor-spar, and smelted in a reverberatory furnace, from which the tin is run off into an iron pot and then cast into bars. The impure tin so obtained is again heated on the hearth of a reverberatory furnace until it fuses, when the nearly pure metal runs off, leaving the less fusible alloys of tin and other metals behind. The molten tin is collected in an iron pot, and kept hot, while it is stirred with a [illegible]od, which causes the greater part of the impurities to [illegible] form of a scum. This is skimmed off, and the [illegible] in moulds, the ingots thus obtained being the qua[illegible] the more finished products are manufactured.

Uses.—As ordinary water and air have very little effect on tin, the metal is extremely useful. It is very largely employed as a protective coating on iron; the thin sheets used for making domestic utensils, &c., and commonly known as "tin", are really tinned iron. Pipes of tinned iron and tinned lead are also used for the conveyance of water, but lead pipes so treated are not of much value on account of the difficulty of making the joints without damaging the coating of tin. Tubes of solid tin inserted in lead or wrought-iron pipes are much more satisfactory. Copper sinks, baths, &c., are often coated with tin by being dipped into a bath of the molten metal. Plain copper sheets after being dipped in the bath of tin are sometimes beaten evenly with a planishing hammer, in order to incorporate the two metals, and are then known as "tinned and planished" sheets. These are used for baths, sinks, the tops of bar-counters, and other fittings.

Alloys.—Alloyed with other metals tin is largely used by the plumber; solder and pewter are alloys of tin and lead, gun-metal and bronze are alloys of tin and copper, and Britannia-metal of tin, antimony, and copper.

Amalgam.—Tin and mercury form the amalgam used for "silvering" mirrors.

5. *ZINC*

Chemical symbol, *Zn*.
Atomic weight, 65.
Specific gravity, 6·9 to 7·2.
Melting-point, 790° F.
Weight per square foot, 1 in. thick, 35·8 to 37·4 lb.

Properties.—Zinc is a bluish-white metal, crystalline in structure, easily melted, harder than lead or tin, but softer than brass. At high temperatures it burns with a bluish flame. Commercial zinc contains various impurities, —carbon, lead, &c. At temperatures between 212° and 300° F. it can be drawn into wire or rolled into thin sheets; a small proportion of lead increases its ductility. After being rolled or drawn the metal remains more or less malleable, but if greater flexibility is required, it can be obtained by annealing. Zinc soon tarnishes in moist air, and commercial zinc is easily acted upon by sulphuric and hydrochloric acids; hence the rapidity with which it is destroyed in smoky towns, where the air contains traces of these acids.

Manufacture.—There are five or six ores from which zinc is obtained, but the two most important are the carbonate known as *calamine* ($ZnCO_3$) and the sulphide known as *zinc-blende* (ZnS). The ores are converted by calcination into oxide of zinc, which is then finely crushed and mixed with coal and coke, and heated in fire-clay retorts placed in a brick furnace. The zinc escapes from the retorts in the form of fumes, which are condensed and collected in special receivers. The metal is then cast into oblong plates weighing about ½ cwt. each, and known commercially as *spelter*.

Uses.—Zinc is used in the form of sheets for roofing (especially for flat roofs), and for eaves-gutters, rain-water pipes, ventilators, &c., but for these purposes the metal is suitable for country districts only. The excessive moisture of our climate, and the atmospheric impurities due to the imperfect

combustion of enormous quantities of coal, militate against the use of zinc in exposed situations. It is also used for ventilating pipes from gas-stoves, and was at one time freely used for soil-pipes and waste-pipes, for which, however, its corrodibility and lack of strength render it thoroughly unsuitable. As a protection to iron it is still largely employed (see p. 19), and it is a constituent of one of the most useful alloys—namely, *brass*,—and of some others of minor importance, such as German-silver.

Zinc Oxide (ZnO) is a white powder known commercially as *zinc-white*, and used as a pigment. It is obtained by burning the fumes which are given off when calcined zinc ore and coke are burnt in a retort. Zinc-white has not the covering-power of white-lead, but is not blackened by exposure to atmospheric sulphuretted hydrogen, and, as it has not the poisonous effects of white-lead, it is preferred by many painters.

6. *ALUMINIUM*

Aluminium (chemical symbol, Al) is a white and rather soft metal, with a specific gravity of only 2·7, and a melting-point of 700° C. (1292° F.). It is not found in the pure state, but occurs in enormous quantities in the form of clay (silicate of alumina) and of other common minerals. The metal is now being used for a variety of purposes, including cooking utensils, but has not yet been employed to any considerable extent for fittings required by the plumber. It is ductile and of great tensile strength, and is scarcely affected by water or nitric acid. Hydrochloric acid, however, dissolves it, and it is slightly acted upon by organic acids in the presence of common salt (sodium chloride).

Mixed with copper (9 to 19 parts of copper to 1 of aluminium), it forms the alloy known as *aluminium-bronze*.

Aluminium Oxide or **Alumina** (Al_2O_3) is well-known in its impure condition as *emery*, which is an extremely hard crystalline compound used extensively in the form of "wheels" for grinding tools, &c., and in the form of powder for polishing metal-work. In a pure and colourless crystalline state it is known as *corundum*, and some of the precious stones (rubies and sapphires, for example) are the same material naturally coloured by metallic oxides.

7. *NICKEL*

Nickel (chemical symbol, Ni) is a lustrous white metal, hard but malleable. It is chiefly used for "electro-plating" other metals, and forms one of the components of certain alloys, known collectively as *white-metal*. These alloys are used by the plumber in the form of tubes, traps, taps, &c., and are also employed for many other purposes, such as coins and spoons.

CHAPTER III

ALLOYS

Alloys are mixtures of metals, and are usually prepared artificially by fusing the metals together. In some cases the mixture is not merely a mechanical one, but there is a certain amount of chemical union. The properties of an alloy are not as a rule a mean between those of the metals of which it is composed. Its melting-point and specific gravity, for example, may be above or below the mean, and the alloy itself may be stronger or harder or more ductile than any of its component metals.

The principal alloys used by the plumber are *solder* (lead and tin), *brass* (copper and zinc), and *bronze* and *gun-metal* (copper and tin). *Pewter* (lead and tin), *German silver* (copper, nickel, and zinc), *Britannia-metal* (tin, antimony, and copper), and some others are also used. An alloy containing mercury is known as an *amalgam*.

Solder.—*Plumbers' solder* is of the kind known as "soft", and is an alloy of tin and lead. There are three common varieties: (1) *coarse*, containing 1 part of tin and 2 parts of lead; (2) *common*, 1 part of tin and 1 part of lead; and (3) *fine*, 2 parts of tin and 1 part of lead. They are all white and melt at temperatures lower than the melting-point of either metal. For soldering pewter (which is itself an alloy of tin and lead), a little bismuth is added to render the solder more readily fusible. *Wood's fusible metal*, which melts at 150° Fahr., consists of 4 parts of bismuth, 2 of lead, 1 of tin, and 1 of cadmium. For brass, the common plumbers' solder is sometimes used, or a solder consisting of 2 parts of tin and 1 of antimony.

Hard solders are used for uniting brass, copper, iron, &c. (see p. 27). "Silver solders" are used for the same purpose, and melt at lower temperatures than ordinary hard solders. The alloy is sometimes made with equal parts of silver and brass, and a cheaper variety with equal parts of silver, brass, and zinc. Other solders are used by goldsmiths and silversmiths.

Pewter.—This is an alloy containing 3 or 4 parts of tin and 1 part of lead. It is bluish-grey in colour, takes a bright polish, and is still used for the fittings of hotel bars and for utensils of various kinds, but not to the same extent as formerly. Some pewter contains copper, &c., and old pewter as a rule contains a larger proportion of silver than modern pewter, probably because the silver was not at that time so carefully extracted from the lead as at the present day.

Brass.—Brass is an alloy of copper and zinc. Its specific gravity ranges from 7·82 to 8·5; melting-point, from 1690° to 1900° F.; and weight per square foot, 1 in. thick, from 40·7 to 44·2 lb.

Composition.—"English brass" is said to contain 2 parts of copper and 1 of zinc, and "Dutch brass" 3 to 5 of copper and 1 of zinc, but the proportions are varied according to the purpose for which the alloy is required. Thus, 2 or more parts of copper and 1 of zinc form an alloy which is very ductile, malleable, and tough, but which cannot be forged when hot: 1½

part of copper to 1 of zinc yield a harder and less ductile alloy, known as *Muntz-metal*, which can be forged when hot; and an alloy composed of approximately equal parts of the two metals is crystalline and brittle. Some "brass" contains lead and tin in addition to copper and zinc; thus, stop-cock metal is said to contain 28 parts of copper, 7 of zinc, 7 of lead, and 1 of tin, and is therefore neither true brass (copper and zinc) nor true gun-metal (copper and tin). A very small proportion of iron is sometimes added to the copper and zinc to increase the strength of the alloy. A small proportion of lead increases its ductility, but larger quantities render it brittle.

Properties.—The colour of brass is yellow, but varies according to the composition, becoming paler as the proportion of copper is reduced. Brass is harder and cheaper than copper, and can be cast, rolled, hammered, and drawn into tubes and wire. It takes a bright polish, and is not seriously affected by ordinary atmospheric influences or by water. Separate pieces can be joined together by *brazing*. The hardness of malleable brass, containing 4 parts of copper and 1 of zinc, is rather less than one-half that of cast-iron.

Manufacture.—In making brass a small amount of scrap-brass is sometimes melted first in a crucible, and the copper is then added and melted; the zinc, after being heated, is put into the crucible, special precautions being taken to prevent the escape of the zinc in the form of fumes. The molten brass may be poured into moulds to form ingots (in the same way as pig-lead and pig-iron), which can afterwards be remelted, or may be poured directly into sand-moulds of the required pattern to give finished castings at one operation. The surfaces of the castings are of course somewhat rough, and may be smoothed by turning, or by polishing on an emery wheel, or by manual labour. Brass plates are often cast between marble blocks, and are reduced to the required thickness by being passed through a succession of rollers. The sheets must be annealed at intervals. Brass tubes may be either solid-drawn, or formed with a longitudinal seam, united by brazing.

Uses.—Brass is largely used by the plumber for taps of various kinds, and the waste and overflow fittings of baths, lavatories, &c., and also for traps and waste-pipes, tubes for various purposes, connections between pipes of different materials, unions, gas-fittings, pump-barrels, and many other fittings. Brass tubes are made in different ways, almost exactly as described for copper tubes in Chapter II.

For ornamental work the polished surface is often lacquered. Brass may also be nickel-plated, as in the case of expensive taps and waste-fittings, &c., or silvered, as in many electric-light fittings, or steel-bronzed, as in switches, bell-presses, &c.

Brazing is the name given to the process or operation of uniting two pieces of brass or copper by a kind of solder. "Spelter" is the usually employed for brass, and consists of equal parts of copper but the proportions may be varied according to the class of w hard solder is made from 3 parts of copper and 1 of zinc. copper, the solder contains as a rule $1\frac{1}{3}$ part of copper to 1

solder may be used in the form of wire, or may be pounded in a mortar and applied dry or mixed with water. The edges to be united must be filed bright, and covered with borax to act as a flux and to prevent oxidation, as this would interfere with the thorough union of the metals. After the solder has been applied, the joint is heated by a blow-pipe, or in some other way, until the solder fuses and the zinc in it burns with a pale-blue flame. A few taps with a hammer may assist the flushing of the solder, and cause it to fill the joint thoroughly. If the work is properly done, brazed sheets may be rolled without injury to the joint.

Bronze, Gun-metal, &c.—Any alloy of copper and tin may be termed bronze, but as the proportions of the two metals vary very widely, according to the purposes for which the alloy is required, different names have been given to alloys of different composition. The term *bronze* may with advantage be here restricted to alloys rich in copper, which are therefore of a reddish colour when untarnished. This description would apply to alloys containing from 10 to 20 parts of copper to 1 of tin. Such alloys are occasionally used for casements, and more extensively for door-fittings, but not often for the fittings required by the plumber. Statuary bronze varies very much in composition, some of it containing about 10 parts of copper to 1 part of tin, while in other cases a smaller proportion of tin is used, and small quantities of lead and zinc are added. By the admixture of various metals, coloured bronzes are obtained—black and dark-green being the most common. The ordinary reddish-coloured bronze tarnishes on exposure to the air, or to acid fumes, to a reddish-brown or brown colour, as seen in the so-called "copper" coins.

Recent tests by Messrs. Calvert & Johnson show that the hardness of "very hard" bronze containing 86·5 per cent of copper and 13·5 per cent of tin (or about 6½ to 1) by weight, is 90 per cent of the hardness of cast-iron; a "hard" bronze suitable for machine-bearings, and containing 88·2 per cent of copper and 11·8 of tin (approximately 7½ to 1), has a hardness 79 per cent of that of cast-iron. Bronze alloyed in the proportion of about 9½ to 1 is of medium hardness, and "soft" bronze suitable for toothed wheels contains about 10½ parts of copper by weight to 1 of tin.

Gun-metal.—To the plumber the most familiar kind of bronze is that known as *gun-metal*, which contains from 5 to 10 parts of copper (generally, however, 8 or 9) to 1 part of tin. The name was applied because alloys of approximately these proportions were formerly used in the casting of bronze cannon. Gun-metal is one of the strongest alloys of copper and tin, and is much used for water-taps, the waste-fittings of baths and lavatories, casements, door-handles, machine-bearings, &c. Its ultimate tensile resistance is about 12 tons per square inch. The colour varies according to the proportion of the two metals, some gun-metal being almost indistinguishable from brass. Not infrequently zinc and lead are substituted for some portion of the tin, as in the case of "stop-cock metal" (see *Brass*), or zinc only is added, as in the case of "copper" coins, which consist of 95 parts of copper, 4 of tin, and 1 of zinc, the last increasing the hardness of the alloy.

Bell-metal contains from 2 to 4 parts of copper to 1 of tin.

Phosphor-bronze is a harder and more tenacious bronze, in which tin

phosphide is used instead of metallic tin. This alloy is used for machine-bearings, pump-rods, &c., and contains 1 part of tin to about 13 of copper.

Aluminium-bronze is an alloy of 9 to 19 parts of copper and 1 part of aluminium.

White-metal.—Various alloys may conveniently be classed together as "white-metal".

German-silver is an alloy of copper, nickel, and zinc, the best containing about 4 parts of copper, 2 of nickel, and 2 of zinc; sometimes a small proportion of lead is added. The best electro-plate is German-silver plated with real silver.

Britannia-metal is a softer alloy, containing from 80 to 90 per cent of tin, 8 to 16 of antimony, and 1 or 2 of copper, with occasionally a little zinc.

These are the two principal varieties of white-metal, but nearly every manufacturer has a formula of his own, so that the hardness and strength of the different white-metals vary within somewhat wide limits.

Babbitt's Mixtures are alloys which are largely used for machine-bearings, and are interesting as showing the different metals and proportions adopted:—

	Copper.	Tin.	Zinc.	Lead.	Antimony.
Genuine	4	88·5	...	...	7·5
Softened with lead	3·5	78·5	...	11·4	6·6
For propeller bushes	5	26	69	...	...
Anti-friction metal	6	14	80	...	...

White alloys are now used for the taps and waste-fittings of baths, lavatories, &c., and for tubes of various kinds, towel-airers, bath-sprays, and other fittings required by the plumber. They are usually either *electro-plated* or *nickel-plated*.

Electro-plating consists in depositing by electrolysis a thin coating of real silver on a body of commoner metal. In *nickel-plating*, nickel is substituted for the silver. Sometimes the fittings mentioned above are made of brass or gun-metal, either electro- or nickel-plated, but a hard white nickel alloy is much better, as the yellow metals, when exposed in patches by the wearing away of the plating, spoil the appearance of the fittings. A serious objection to some of the white-metals is that they are not absolutely impervious to water.

CHAPTER IV

MARBLE, SLATE, POTTERY, GLASS, ETC.

Marble.—This name is commonly ... one which is sufficiently compact to take a high p... narbles" is almost infinite, but among those most ... the following (see Plate I):—Sicilian,

Jaune Lamartine, from France; and two varieties of Rouge Royal from Belgium.

Three varieties of the more costly Skyros marble are shown in Plate VI; these are quarried in the small island of Skyros in the Grecian Archipelago. The well-known Verde Antico and some other green marbles are grouped together in Plate XXX, and Algerian marbles and other stones in Plate XXXII.

Marble is used by the plumber in sanitary fittings of various kinds, especially for the slabs and skirtings of high-class lavatories and the divisions between stall-urinals. It is also used for floor-slabs under baths, lavatories, &c., in lieu of lead safes, and for the wall-linings and floors of sanitary rooms. Occasionally marble baths cut out of a solid block are adopted.

In fixing marble, particularly if it is delicately tinted, the joints must be made with Portland cement or plaster of Paris, and not with putty, as the oil in the latter would stain the marble. The slabs for wall-linings are usually ¾ in. in thickness, and may be fixed with countersunk brass screws, the heads of which are covered with marble plugs or caps, or the joints of the slabs may be rebated to allow for "secret-fixing".

Onyx is a beautiful and delicately-shaded variety of stone, consisting principally of quartz, and having usually alternate bands of white and black or white and brown. It takes a high polish and is in parts translucent. It is used for the slabs and skirtings of high-class lavatories, &c. There are two principal varieties, sometimes known as *Mexican Onyx* and *African Onyx*, three specimens of the latter being shown in Plate XXXII.

Alabaster is a variety of gypsum (the raw material from which *plaster of Paris* is made). It is softer than marble, but takes a high polish, and is sometimes used for the slabs of lavatories, wall-linings, &c. The best varieties are pure white or delicately tinted, finely grained, and translucent.

Slate is a fine-grained argillaceous rock, which can be easily split into thin slabs or sheets. It is hard, dense, and durable, and is extensively used for roofing, and to a smaller extent for cisterns, sinks, urinals, larder-shelves, and other purposes. For roofs, the surfaces of the "slates" are not wrought in any way, but for sanitary work they are "rubbed" or polished, and urinal-slabs are often enamelled in plain colours or to imitate marble. Slate cisterns for storing pure water are made of slabs bolted together, the joints being grooved and made water-tight with neat Portland cement; red- and white-lead ought not to be used, as they contaminate the water.

Pottery.—Three kinds of pottery are used by the plumber—namely, earthenware, stoneware, and porcelain. There is no fixed line of demarcation between the several varieties, but, speaking generally, it may be said that earthenware is fired at a comparatively low heat, and, when unglazed, as in the case of a common flower-pot, is porous and can be scratched with a steel point; stoneware is fired at a higher temperature, and is harder and denser; and porcelain is fired at the highest temperature, so that the materials of which it is composed are fused or partly fused together in the kiln, thus producing an extremely hard and dense ware, the best kinds of which are, even when unglazed, practically impervious to water, and cannot be scratched with a steel point.

No. 6. SKYROS—LIGHT (GREECE)

No. 7. SKYROS—DARK (GREECE)

Earthenware is made from clays of various kinds, mixed, in some cases, with calcined and powdered flints, lime, &c., and may be red, yellow, or white in colour, according to the nature of the materials. Agricultural drain-pipes are of common red or buff earthenware. The yellow earthenware made from "fire-clay" is largely used for strong water-closets, sinks, baths, and other sanitary fittings, the surface being protected by an impervious glaze of porcelain enamel. Earthenware of lighter colour is used for the cheaper kinds of lavatory-basins, water-closets, &c.

Stoneware is also made from clays of different kinds mixed with sand and other materials, and is principally used for drain-pipes and their accessories, and for strong and heavy sanitary fittings, such as urinals and sinks, &c. The surface is usually glazed by throwing common salt (chloride of sodium) into the kiln; the salt is volatilized by the heat, and the sodium, combining with the silica on the surface of the pottery, causes it to fuse and form a thin coating of glass, which, in the best ware, cannot be separated from the body.

Porcelain is made from china-clay (Kaolin) mixed with calcined and powdered flints, calcined bones, sand, &c.; for the cheaper kinds ordinary clay is also added. Thus the following proportions are sometimes observed:—Clay, 19 per cent; china-clay, 11 per cent; powdered flints, 21 per cent; and calcined bones, 49 per cent. In the better varieties the proportion of china-clay is increased. Porcelain is used for the best pottery lavatory-basins, water-closets, &c. Many so-called "porcelain" fittings, such as baths, are really earthenware (fire-clay) porcelain-enamelled.

The manufacture of porcelain and of the finer kinds of earthenware involves a number of processes, of which the most important only can be mentioned. The ingredients must first be ground in water to an extreme degree of fineness, the clay and the other ingredients being separately treated. The milk-like liquids which are thus obtained are then mixed together in proper proportions, and the superfluous water is removed (by evaporation or by mechanical means), until the solid material has the consistency of dough. This is now modelled into the required shape. In an intricate piece of work, such as a water-closet basin and trap, the various parts are separately modelled, and the pieces are then carefully put together in the plastic state. The articles are now slowly dried in a drying-stove, and are then placed in earthenware vessels known as "seggars", piles of which are built up in the kiln. Each seggar forms a sort of small oven, so that the ware contained in it is protected from the products of combustion and from extreme variations of temperature during the process of firing. The firing is continued for one and a half or two days at temperatures suitable for the kind of ware, and the kiln is then allowed to cool gradually, until the seggars can be removed. The ware is now in the "biscuit" or unglazed state, and is unpacked and carefully examined, the defective pieces being sorted out. The more perfect articles are rubbed down, and dipped in a liquid glaze composed of materials finely triturated in w which will form, when fused, either a thin film of glass on the s in the best porcelain and in the common domestic earthenw opaque glaze (as in white-enamelled fire-clay). White-lead

of the glazes, but has now been abandoned by many of the best firms on account of its injurious effects on the health of the work-people. After being dipped, the articles are again packed in seggars and placed in the glazing-kiln, where they are heated until the glaze fuses on the surface. Patterns may be printed on the biscuitware, by means of transfers, before the articles are dipped, and can be seen through the glaze when this has been fused; but for sanitary fittings patterns are objectionable—a plain white surface is more likely to be kept scrupulously clean.

As already stated, salt-glazed stoneware requires one firing only, the glaze being formed in the first kiln by means of salt.

Special names are given by some manufacturers to the pottery of which their best sanitary fittings are made, and in many cases these names are a guarantee of good quality. Stress must be laid on the fact that the quality of sanitary pottery varies enormously, and the article which is cheapest in first cost is usually the dearest in the end. There is often an imperfect adhesion between the glaze and the body, and in cheap ware the glaze "crazes", a net-work of fine cracks being formed which detracts seriously from the appearance. Much cheap pottery is also very fragile, and many cracks in lavatories and water-closets are due to this cause. The biscuit-ware may also be quite porous, and any damage to the glaze leads to foulness, or even to a leakage. Another common defect is caused by the warping of the ware in the kiln; this is often seen in sinks and in stone-ware drain-pipes. The surface is also sometimes uneven. In the best sanitary ware the body is hard, strong, and dense, and semi-vitrified throughout; the surfaces are true; and the glaze is thoroughly adherent and does not craze.

Tiles.—The tiles used for lining the walls and floors around sanitary fittings are usually of earthenware glazed on the surface with white or coloured glazes (see *Pottery*). They are made in various sizes up to about 9 in. square, and from $\frac{3}{8}$ to 1 in. thick, and are laid in Portland cement. Hard and dense pressed tiles, unglazed, are also used for floors. Tiles of opaque glass or porcelain of various sizes, and about $\frac{1}{8}$ in. in thickness, with the backs roughened with coarse sand or fragments of glass, are now made for wall-linings, and are laid in mastic on a cement backing.

Glass.—Usually glass is a lustrous, transparent solid, brittle when cold but tenacious when heated. The composition varies according to the purpose for which the glass is required. Window-glass (including crown, sheet, and plate) is a silicate of soda and lime, but in plate-glass the materials are more carefully selected. The raw materials of which window-glass is made are sand, sulphate of soda, chalk or limestone, powdered anthracite coal or carbon, &c. Broken glass is mixed with these, and small quantities of other substances are usually added to prevent discoloration of the glass by iron or other impurities. Where coloured glass is required, various metallic oxides are mixed with the other materials. Opaque glass "tiles" are now much used, and a coating of glass (known as "vitreous enamel") is often applied to cast-iron baths and other fittings, the interior of iron soil-pipes, &c.

Asbestos is a fibrous mineral, consisting chiefly of silica, magnesia, lime, and oxide of iron. It has the appearance of wool, and the fibres are white, grey, or bluish, and, although brittle, can be easily separated and even spun and woven together. It is non-inflammable, almost imperishable, and a bad conductor of heat, and for these reasons it is largely used as a covering for boilers, steam and hot-water pipes, &c. It is also used for lamp-wicks and shades, fire-resisting slabs, packings for pipe-joints, and in fireproof paints. The balls used in gas-fires are made from ground asbestos and fire-clay, while the filaments in more modern gas-fires are of pure asbestos. It can be ground and made into pulp, and then pressed into sheets on gauze netting; *uralite* is a well-known example of asbestos mill-board.

CHAPTER V

CEMENTS

Portland Cement.—This most useful cement is manufactured from chalk and clay, or from lime and shale, calcined together and then ground to a fine powder. It receives its distinctive name from its resemblance (when "set") to Portland stone.

Uses.—It is almost invariably used to form the joints in stoneware drain-pipes, as a mortar for the brickwork of inspection-chambers, and as the matrix of concrete for the foundations of drains, inspection-chambers, &c. It is also employed for making the joints between pottery closets and iron or brass soil-pipe branches and the joints of slate cisterns, the fixing of various sanitary fittings, and for many other purposes in building-construction and plumbing.

Properties.—When mixed with water, chemical union takes place between the water and the cement, and the mixture "sets" and ultimately hardens into a solid mass resembling stone. The cement has received the name of "hydraulic", on account of its valuable property of setting and hardening under water. After it has set and hardened, it is not affected by ordinary water, but, like all natural stones containing lime, it is freely acted upon by hydrochloric acid. It possesses considerable strength. Briquettes made of good neat cement will, at the age of seven days, have an ultimate resistance to tension of about 450 lbs. per square inch, and at twenty-eight days about one-third more, while briquettes containing 1 part of cement and 3 parts of good sand will have a resistance of about 250 lbs. per square inch at the age of twenty-eight days. The resistance to compression is from five to ten times as much as the resistance to tension. Variations of temperature cause cement to expand and contract, and, as the material is inelastic, contract[illegible] produces cracks, such as are often seen in large slabs of c[illegible]

Composition, &c.—The co[illegible] t varies, but not to such an extent as formerl[illegible] r is to obtain a cement containing about [illegible] nt of silica,

alumina, and other substances. The most important ingredients are lime, silica, and alumina. The time of setting of different cements may vary from a few minutes to several hours, and is determined principally by the composition of the cements, the degree to which they have been calcined, and the fineness of the grinding. A cement containing free lime is dangerous, as the free lime, when mixed with water, expands to about three times its original bulk, and although it may form only a small proportion of the cement, it is often sufficient to cause so much expansion in the whole as to burst off the collars of stoneware drain-pipes. Cements of this kind ought to be "cooled" or "air-slaked" by being spread for some days on a dry floor, so that the free lime may be slaked by the moisture contained in the air. On no account must cement be stored in a damp place. Air-slaking, as a rule, reduces the rate of setting of the cement. Coarse particles in cement are inert, and must be regarded as so much sand; fineness of grinding is therefore of great importance, as any admixture with sand or other inert matter reduces the strength and increases the porosity. Under-burnt cements have often a brownish colour, and are unreliable.

Cement is sold by the ton, and is usually packed in bags containing about 200 lbs. (eleven bags to the ton). Small quantities are sold by the bushel: the weight of a bushel varies according to the nature of the cement and the fineness of the grinding, but, as a rule, it is from 100 to 110 lbs. A finely-ground cement weighs less (bulk for bulk) than a coarse cement.

Cement-mortar.—This is an admixture of cement, sand, and water. The proportions of the cement and sand vary according to the class of work. For ordinary brickwork 1 part of cement is usually mixed with 3 parts of sand by measure; for inspection-chambers, 1 to 2 or 1 to 1; for stoneware drain-pipe joints, 1 to 1 up to 4 parts of cement to 1 of sand; for joints at the outlets of water-closets and in iron drain-pipes, &c., neat cement is used. The sand must be thoroughly clean, and for sanitary work ought always to be washed, as the particles are usually coated with a thin film of clay or mud, which prevents the adhesion of the cement; the particles ought not to be too fine or round, and all large pieces ought to be sifted out. The water, also, ought to be clean, and sufficient only in quantity to combine chemically with the cement and to allow a small margin for evaporation, as excess of water causes drops of water to collect, around which the mortar sets; when the water dries out, small cavities are left in the mortar. On the other hand, an insufficient quantity of water is injurious, as the whole of the cement cannot set and harden. This defect seldom arises from an insufficiency of water in the mixing, but usually from an excessive loss of water by evaporation and by absorption. In hot weather evaporation ought to be checked by protecting the mortar in some way, or by keeping the surface constantly damp; if absorbent materials are to be joined (such as common stock bricks), they ought to be soaked in water before being placed in contact with the cement. In preparing the mortar the cement and sand should be thoroughly mixed dry, and again mixed while sufficient water is being added to form a stiff paste.

The mortar should be made in small quantities and used fresh, as any reworking after it has begun to set is injurious.

Cement-concrete.—Concrete is a mixture of cement, water, sand, and fragments of stone or other hard material. For the protection of stoneware drain-pipes a strong and fairly impervious concrete is required, and the fragments of stone should be of such a size that the concrete can be packed closely around the pipes. The proportions may be 1 part of cement, 1 or 1½ part of sand, and 4 parts of "ballast" broken to pass through a screen with meshes ¾ or 1 in. square. The sand and ballast must be thoroughly clean, and must be well mixed in a dry state with the cement on a clean bed of planks or other flooring. The mixing must be continued while water is being added, and afterwards repeated, and the concrete must then be deposited in position without loss of time, and immediately consolidated by ramming. Concrete must not be disturbed after it has begun to set, and undue loss of moisture by evaporation must be prevented. For the foundations of inspection-chambers, &c., 6 parts of ballast may be used, and the fragments may be larger—up to 2-inch cubes. Porous materials, such as coke-breeze, are unsuitable for the concrete required in sanitary work.

Elastic Cement.—This name is applied to any cement possessing a considerable amount of elasticity or toughness. Various materials are employed, but one of the best cements of this kind for the plumber's use is made by mixing ordinary Portland cement with Stockholm tar instead of water. This is used in salvage operations for plugging holes in ships' bottoms, and would serve many useful purposes in plumbing works, such as the joints between pottery water-closets and cast-iron soil-pipes.

Plaster of Paris is a kind of cement produced by the calcination of gypsum (a hydrated sulphate of lime) at a moderate heat, so that a portion of the water is driven off. If the whole of the water is evaporated, the property of "setting" when mixed with water is greatly impaired. After calcination the material is finely ground, and is ready for use. Keene's, Parian, and some other cements are plaster of Paris treated with alum, borax, &c., to obtain increased hardness. Plaster of Paris, when mixed with water, "sets" by combining chemically with it, gypsum being reformed. It is used by the plumber for making the joints between marble and pottery, &c., as oil putty would stain the marble. Being slightly soluble in water, it is unsuitable for external work. In hardness, imperviousness, and strength it is greatly inferior to Portland cement.

Rust Cements.—These are often used for making water-tight joints in socketed cast-iron pipes (especially heating-apparatus pipes), and in tanks constructed of cast-iron plates bolted together, and also for other purposes. They are, as a rule, composed of iron borings, flour of sulphur, and sal ammoniac, the proportions being varied to suit different circumstances. A quick-setting cement may be made with 96 parts of iron borings, 2 parts of sal ammoniac, and 2 of flour of sulphur (by weight). For slow-setti cements the proportion of sal ammoniac must be reduced. Somet flour of sulphur is omitted, and only 1 oz. of sal ammoniac is 1 cwt. of iron borings; but such a cement would set too slow

use in ordinary circumstances. It is, however, better to use too little sal ammoniac than too much, as an excess may cause the cement to expand to such a degree as to burst the socket of a pipe. The ingredients should be mixed dry, and a sufficient quantity of water added to make a stiff paste; the temperature soon rises appreciably, and, after being again worked up, the cement is ready for use.

CHAPTER VI

MISCELLANEOUS MATERIALS

India-rubber is a flexible and elastic substance (sometimes known as caoutchouc) prepared from the juices of various trees. The principal sources of supply are Brazil, the central portions of West Africa, and the East Indies. Incisions are made in the trees, and the juices are collected and dried. The raw material is purified by being boiled in tanks and afterwards shredded in running water. It is then compressed between rollers.

India-rubber is used by the plumber in the form of washers or packings for flange-joints in pipes; in the form of rings for expansion-joints in socket-pipes, and for the waste-plugs of lavatories and other fittings, the washers of hot-water taps, the cones for connecting flush-pipes to water-closet basins, the buffers of water-closet seats and flushing-cisterns, hose-pipes, the insulation of electric wires, &c.

Nearly all the india-rubber used for these purposes is vulcanized. This process consists essentially in the addition of sulphur to the natural material, and subjecting the mixture to heat in a vulcanizing chamber. For the hard varieties, such as those used for the washers of hot-water taps, the sulphur may be as much as one-third of the india-rubber (by weight), while for the softest varieties it may be only one-fortieth. Other materials are also sometimes added, including French chalk, litharge, and various colouring matters. *Vulcanite* is the name given to some of the hard varieties of vulcanized rubber.

The natural india-rubber hardens at a temperature of 32° F., and becomes soft when boiled. It is insoluble in water and is not affected by alkalies or dilute acids, but is soluble in naphtha, petroleum, benzol, the essential oil of turpentine, &c. Vulcanized india-rubber is not affected to the same extent by changes of temperature, or by the spirits and oils just mentioned. Indeed, the hard varieties are almost entirely unaffected.

Gasket is the name given to a cord or rope for attaching a sail to the yard of a ship. In plumbing, however, it is the vegetable fibres of which ropes are made. These are usually of hemp or flax, and are used by the plumber in making joints in water-pipes, drain-pipes, &c. For water-pipes, "white" (*i.e.* not tarred) gasket is the best, as it does not contaminate the water, while for drain-pipes and soil-pipes tarred gasket is better, as it does not rot so readily.

Tallow is the fat of oxen and sheep "rendered" or melted. Many years ago Russia was the principal source of the imports of tallow into this country, and the name "Russian tallow" still survives, although nearly all the imported tallow now comes from North and South America. Tallow is used by the plumber for filling the "seals" of manhole-covers, in order to render the joints air-tight. It is also employed as a flux in soldering lead; as a rule, a tallow candle is rubbed over the parts to be soldered, the operation being known as "touching".

Linseed-oil is extracted from the seed of flax, and is used in the manufacture of paints, varnishes, &c. It is usually amber-coloured, but the purest is nearly colourless. "*Cold-drawn*" or "*raw*" *linseed-oil* is extracted from the crushed and ground seeds by hydraulic pressure without any application of heat, and is the purest; but much of the oil sold as "raw" is extracted at a steam heat of about 200° F., as a greater quantity of oil can thus be obtained. *Boiled* or *drying oil* dries more rapidly on exposure to the air, and is obtained by boiling the raw oil, either alone or with litharge, white-lead, &c.

Putty is a mixture of *drying oil* (that is to say, linseed-oil boiled with litharge, &c.) and *whiting* (chalk ground and washed to free it from impurities). A small quantity of white-lead is sometimes added. Putty is used by the glazier for bedding glass in wood-work, &c., and occasionally by the plumber for joints in pipes, but it is quite unsuitable for any joints which are required to be air-tight or water-tight, as the drying of the oil causes it to crack.

Turpentine.—Crude turpentine is a resinous substance secreted by various pine-trees, &c., and is obtained by making incisions in the bark during the summer months. The crude turpentine is distilled with water in a retort, when the water and oil of turpentine pass over, leaving the resin behind. The turpentine used by the painter is the oil of turpentine, and is a powerful solvent of resins and oils. Resin is used by the plumber in the operation of soldering.

Resin.—Resins are obtained by the distillation of the secretions from certain pines and other trees, and are extensively used in the manufacture of varnishes, &c., and also by the plumber in the operation of soldering. They are translucent solids (consisting of carbon, hydrogen, and oxygen), easily melted by heat, and inflammable.

Borax is a sodium salt ($Na_2B_4O_7$) manufactured from boracic acid and carbonate of soda. It is soluble in water, and possesses the properties of dissolving metallic oxides (such as zinc-white, red-lead, &c.), and of serving as a flux when heated with other metals. It is therefore used in the processes of enamelling iron, pottery, &c., and by the plumber to form a thin coating of glass on the bright edges of metals in order to prevent oxidation during the operation of soldering or brazing the metals together.

Spirits of Salt.—This is the name commonly given to an aqueous [illegible] of hydrochloric acid (HCl). The ordinary commercial solr[illegible] various impurities, and is occasionally used for remov[illegible] organic matter which collects in water-closet basins, &c. [illegible] poured into the standing water, and allowed to remain [illegible]

usually suffice, but the practice cannot be generally recommended, as the acid may injure the fittings. Spirits of salt are also used as a flux in the operation of soldering zinc and galvanized iron. For soldering copper and brass the flux employed is chloride of zinc, which is obtained by dissolving zinc in spirits of salt.

Sal Ammoniac.—This is the common name for ammonium chloride (NH_4Cl). It is sold in the crystallized state, and is used by the plumber for recharging the cells of electric bells, and also as an ingredient in rust cements (see p. 35). It is soluble in water, 100 parts of water at a temperature of 50° F. dissolving about 33 parts of the salt, and at a temperature of 212° about 77 parts.

Smudge.—Smudge or soil is a composition applied by the plumber to lead pipes, &c., to prevent solder adhering to the lead while a soldered joint is being made. It is composed of lampblack and a little chalk, well ground together to a fine powder, and mixed with size or glue, the whole being gently heated in an ordinary soil-pot or in a carpenter's glue-pot. Sometimes a little brown sugar or beer is added.

Mica is the name given to a group of complex silicates of aluminium together with magnesium, &c., which can be easily split into thin sheets. Some of the varieties are translucent and nearly colourless, and were formerly used largely in the place of glass. The "talc" chimneys for incandescent gas-burners are an example of the modern use of the material, and it is also employed for the flaps or valves of inlet-ventilators in systems of drainage and for other purposes.

SECTION II

THE ELEMENTS OF PRACTICAL PLUMBING

BY

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SECTION II
THE ELEMENTS OF PRACTICAL PLUMBING

CHAPTER I

PLUMBERS' TOOLS AND THEIR USES

The plumber must be equipped with proper tools to enable him to carry out successfully the work entrusted to him. He should see that they are of the best quality and pattern, and that they are kept in good condition, so that work may be easier to him and the result of his labour satisfactory to his employer. A rough or bumpy-faced dresser is a bad tool to use on a piece of sheet-lead, leaving marks that can never be completely effaced, and causing loss of time and temper to the worker. A blunt or broken cutting-knife, chisel, or shave-hook is not a handy or expeditious tool, nor is a dull rasp or file likely to give satisfaction. The tools in a workman's kit should therefore be kept in the cleanest and best condition. It only takes a few minutes to remove a rough place from a dresser, mallet, or bossing-stick, and to keep steel and iron tools free from rust and the usual greasy filth and red-lead that stick to them so readily. The plumber and his mate should take a pride in keeping their tools in perfect condition. Some of the tools are expensive, but many, especially those used for lead-working, can be, and often are, made by the workman himself. We will enumerate and describe the tools usually found in a plumber's kit, and briefly indicate their uses.

Dressers.—These are of various shapes and sizes, according to the whim of the user and the nature of the work to be done. They are made of hornbeam, holly, or beech-wood for common roof-work, and of box-wood for finishing and special work. Many men find it best to buy the wood in the rough and make the tools at home, as they can thus get them of the exact shape they like. The ordinary roof-dresser (fig. 9) must have a smooth face, sides, and back, the edges slightly rounded, and the handle well clear of the striking surface, to enable the user to work it freely without injury to his knuckles. The flat is best slightly rounded, so that the outside edges may not unnecessarily mark the surface of the lead. Hornbeam and holly make good dressers, being of a tough and springy nature. They should be made for either hand; to be ambidextrous is a

Fig. 9.—Dresser

great help to a plumber, as his work often "comes awkward". On no account should a hammer be used on a wooden tool, as it soon destroys the surface of the wood and ruins it for good work; a wooden mallet is the proper tool to use.

A bossing-stick or **dresser** (fig. 10) is made of box-wood, and is used for working-up corners, breaks, and finials, or, in fact, for any piece of work where lead has to be bossed or worked to a shape. It must be rounded in every part and have a perfectly smooth surface; no rough or worn parts on it can be tolerated, for a few blows with a defective tool may spoil an elaborate piece of work, by causing a mark or bruise which leads to a buckle, and produces a crack which spoils the job.

Fig. 10.—Bossing-stick

A pipe-bending dresser (fig. 11) is somewhat similar to a bossing-dresser, but flatter, broader, and bent at the striking-part. It is used for working the lead in the formation of bends and offsets on lead pipe.

Fig. 11.—Bending Dresser

A setting-in dresser is a piece of straight-grained hornbeam about 15 in. long, 3 in. deep, and 1½ in. thick, V-shaped, with a rounded edge and projecting ends, and is used for marking the lead to form upstands in gutters and lead flats, or for chasing-in the members of mouldings. This is a very useful tool, and much more convenient in many situations than an ordinary dresser.

Mallets are generally made of box or lignum-vitæ wood, and are of various shapes and sizes. The bossing-mallet is partly egg-shaped, larger at one end and tapering to a rounded point at the other. It must have a smooth surface and be rounded in every part. A hole is bored through the mallet, into which a strong ash handle is accurately fitted and wedge-fixed. It is used for bossing, drawing or driving lead from one part to another, the end or side being used as necessary.

Fig. 12.—Bossing Mallet

Another mallet with a head square at one end and wedge-shaped at the other is used for striking dressers, setting-in tools, and chase-wedges.

The chase-wedge is a serviceable tool if carefully and skilfully used, but dangerous to the work in the hands of a careless or incompetent plumber. They are made of hornbeam or soft box-wood, and of different shapes and sizes; the edges are blunted or rounded as necessary, but on no account should they be sharp. They are used for working lead into acute angles, as,

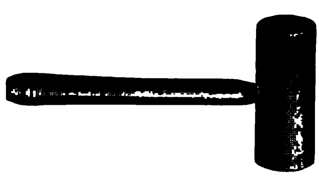


Fig. 13.—Round Mallet

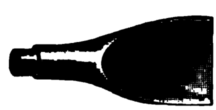


Fig. 14.—Chase-wedge

for example, for driving the overcloak lead into the bottom of gutter drips, or into the return angles of rolls on lead flats. A small steel plate (fig. 15) with rounded corners and curled handle should be placed on top of the undercloak lead, so that the driving with the chase-wedge may not injure the work underneath.

Fig. 15.—Steel Plate for use with Chase-wedge

A bevel is a tool used for taking angles for correct setting-out of lead in dormers, gutters, bays, and flashings. It is made of hard wood with a brass bolted joint and thumb-screw.

A set-square of steel or iron, with measured dimensions on both sides, is also needful for the same purpose.

A two-foot fourfold **box-wood rule** is another necessary tool, but most plumbers carry a two-foot steel rule as well.

Knives.—A plumber's *pocket-knife* (fig. 16, No. 1) is a strong-bladed one with extra thick hinged rivet and firm horn or vulcanite handle. A *draw-knife* (No. 2), for lead-cutting, is a strong hawk-pointed blade fixed in a wood or horn handle, and provided with a sheath, to save it from being damaged or doing damage when placed among other tools; a chalk-mark is struck on the lead at the place required, and the blade is drawn along the mark, the sharp point being pressed into the surface of the metal but not driven through. The cut lead can then be pulled or rolled apart with ease. The blade is in many cases fixed into a long wooden handle, and a rope is attached to the blade and pulled by the plumber's mate, while the plumber guides the knife by the long handle. A *chipping-knife* (No. 3) has a strong steel blade with a pair of leather pads riveted to the handle, and is used for cutting off lead where it is too thick for the draw-knife. A hammer is used to drive the blade through the metal.

Fig. 16.—Plumbers' Knives: No. 1, Pocket-knife; No. 2, Draw-knife; No. 3, Chipping-knife.

Plumbers' hammers are of cast steel with a true round face and straight pane, the handle of good straight-grained ash, well fitted and wedged into the head, so as to be evenly balanced and "at home" in the hand of the user. The shape described is found most convenient, the straight pane enabling the workman to drive pipe- and wall-hooks in awkward corners. Two hammers, one large and one small, are necessary.

Screw-drivers of varied sizes, made of tough spindle steel, with strong flat-shaped handles, are necessary, the edges well and truly sharpened and tempered, so that a large or small screw may be easily drawn. The plumber has often to take down and replace the polished wood fittings of baths, lavatories, and water-closets, when a carpenter is not available, and should be able to do this without injury to the finished work.

A turnpin or **tampin** (fig. 17) is made of hard wood (box or lignum-vitæ) tapered in shape, and is used for opening the ends of pipes in preparation for jointing; two or three sizes are necessary for pipes from ½ in. to 4 in.

Fig. 17.—Turnpin

Mandrels (fig. 18) for 1½-in. to 2-in. pipes are pieces of straight-grained oak about 15 in. long, perfectly round, the exact size of the bore of the pipe, and slightly tapered at one end and rounded at the other. The length of pipe required is put on the bench and straightened, the tapered end of the mandrel is entered into the pipe and forced forward with a wooden mallet and a hardwood driving-rod. As it passes through it forces out all dents and buckles; the lead pipe is then dressed smooth on the outside with a soft dresser

Fig. 18.—Mandrel and Bobbin

and a piece of sheet-lead called a flapper. This should leave the length of pipe exactly cylindrical, straight and smooth, and ready for fixing.

Dummies are generally home-made tools, and are of various lengths and weights. A hand-dummy is about 15 in. long and consists of a malacca cane handle with a bulb of solder or hard lead attached to the end. The method of doing this is to cut grooves across the end of the cane and fix screws into it with the heads slightly projecting. The metal is run into a sand-mould, the cane forming the core, and the bulb is then rasped and filed to a smooth surface. This dummy is used in working out the throats of short lead bends or any dent in wrought-lead work. Longer dummies have handles of stout gas-barrel, the bulbs being soldered and wiped on; they are used for bends some distance from the end of the pipe.

Bobbins (fig. 18) and **driving-weights** are used for passing through bends to ensure that the bore of the pipe shall be exactly the size, and the surface inside and out free from dents. The bobbin is of lignum-vitæ or box-wood, partly egg-shaped, with a smooth surface and of the size of the pipe to be operated on; a hole is drilled lengthways through it for a strong cord to pass freely through. The weight is of a similar shape but smaller, and is of brass, cast in two halves and screwed together, with a hollow inside for fastening the cord, which also passes through the weight. Both bobbins and weights must be smooth all over and have no sharp angles. When used, the cord is passed through the bent pipe and the bobbin entered into it; the pipe is butted hard up against a stop on the bench, and the cord with the weight attached is held tight by the plumber at one end and the mate at the other, and is pulled to and fro until the bobbin is drawn through the bend. The weight must not be allowed to wobble, as it would then be liable to injure or dent the work.

Steel Spiral Spring.—In bending heavy pipes, from 2 in. downwards, a spiral spring (fig. 19) is sometimes used. This enables the work to be done quicker than with dresser or bobbins. It is made of finely tempered steel

of the size of the pipe, tapered at one end and with a strong bent eye or handle at the other. The spring is forced by a spiral twist into the pipe, to the place where the bend is required, and the pipe bent to the required shape, the spring preventing the lead collapsing. It is then twisted up tighter by means of a hook passed through the eye, which reduces its size and enables it to be withdrawn from the bend. This tool should not be used for pipes that are thin in substance, as it tends to weaken and sometimes fractures them at the outside radius of the bends.

Fig. 19.—Steel Spiral Spring for bending Lead Pipe

Solder-pots (fig. 20) are of cast-iron and made of various shape, size, and strength. These are generally left in charge of the mate, and he has to be careful of his charge; for if left unnoticed too long in a kitchen range, exposed to the fierce heat, they easily get burnt out, and the metal they contain lost. A solder-pot should never be heated to a red heat, and must be jealously guarded from contamination with zinc, a metal which completely spoils solder for joint-wiping.

Fig. 20.—Cast-iron Solder-pot

Ladles (fig. 21) are of wrought-iron, the bowl being hemispherical with a clean bent pouring-lip, and the handle may be bent double to form a good handhold when in use. Three of different sizes are required.

Fig. 21.—Wrought-iron Ladle

Soldering- or **plumbing-irons** (fig. 22), though not used so much as they were a few years ago, are yet necessary. Many plumbers think it reflects on their skill as mechanics to use them, but this ought not to be. In many a situation work is easier and certainly more safely done with an iron than by the use of a blow-lamp. They are egg-shaped bulbs of wrought-iron with a hooked handle, and are used for keeping the metal hot on a joint while it is being formed and wiped. They must be kept free from scale, and never overheated; a dull-red colour is about the heat required, and previous to being handed to the workman the handle should be cooled and the hot bulb filed to a clean smooth surface. It is better to use two irons at the right heat than one too hot, which would burn the metal and spoil the joint.

Fig. 22.—Soldering-iron

Shave-hooks (fig. 23) are used for preparing the surface of lead to be soldered by removing the oxide or rust from the surface, so as to let the flux adhere to the clean metal. They are made in many shapes—straight, bent, spoon, and gauge-hook patterns—and are triangular pieces of plate steel with sharp edges riveted to a wrought-iron shank, which passes through a wooden handle and is clenched together at either end. Care must be taken in their use not to dig the edge into or cut the lead at the edge of the cleaning, and so weaken the pipe at the junction of the solder and the lead; the hook should be evenly, firmly, and yet lightly passed along the surface, and every part left clean and at once rubbed over with the flux to be used; a hair's-breadth of unshaved metal will inevitably produce a leaky joint.

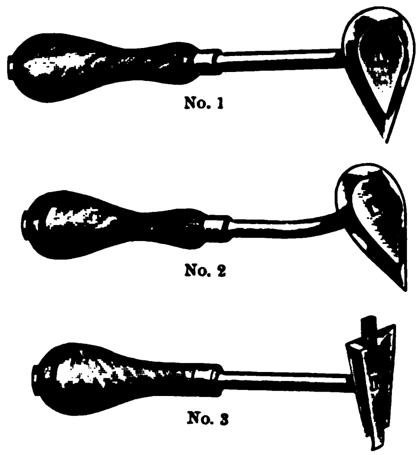


Fig. 23.—Shave-hooks: No. 1, straight; No. 2, bent; No. 3, for soil-pipes

A bending-bolt (fig. 24) is of tough wrought-iron or soft steel, made in an ʃ form, the ends being of different thickness, and is used for straightening the short ends of pipes, or widening openings for branch joints. A small hole is first made in the pipe where the branch is to go, with a short shell gimlet, the end of the bolt is inserted, and the lead driven outwards with a small hammer till the required size of opening is attained. In using this tool take care not to injure the inside surface of the pipe. Two bolts of different length and thickness are necessary.

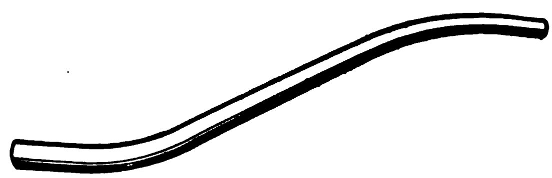


Fig. 24.—Wrought-iron Bending-bolt

Copper soldering-tools (fig. 25) are named bits or bolts in different localities, and are generally of two patterns, "straight" and "hatchet". The straight tool is a piece of square copper fitted and riveted into a wrought-iron handle, and tapering to a point; the iron handle is fitted into a loose wooden handle for grasping it for use. The hatchet tool is in form similar to a common hatchet, the copper head passing through and riveting over a circular iron ring to which is attached a hollow iron handle of approved length. The copper head can thus be turned round to suit the

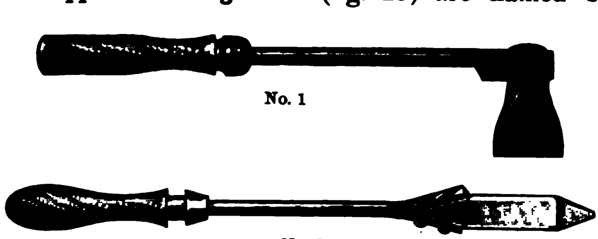


Fig. 25.—Copper Bits: No. 1, Hatchet; No. 2, Straight

position of the joint or soldering to be done. They are mostly used by plumbers for tinning brass-work where it is to be wiped to lead. In many parts of the country they are extensively used for small joints on service-pipes and on lead waste-pipes. Before the introduction and use of drawn-lead soil- and waste-pipes, plumbers were very skilful in their use in the manufacture of seamed pipe. The beginner has to be careful not to over-heat the copper, and to see that the working face of the tool is well and smoothly tinned with solder. To do this the point or edge of the tool is carefully filed and then dipped in a flux of powdered resin, or rubbed on a sal-ammoniac block, and the solder at once rubbed and melted on the filed surface. If the copper is heated red-hot, the solder is at once burned off, and only a moderate heat allows the tinning to be done. In tinning brass, copper, or other metals, the flux is rubbed on the surface and the solder applied with the tinned copper soldering-tool.

Soldering- or **wiping-cloths** form an important item in a plumber's kit. They are for the most part made of moleskin cloth, but some men use best quality bed-ticking cloth. Many thicknesses of material are used, and the sizes vary from the large cloth required for the 4-in. and 5-in. joint to the small cloth used in wiping small branch joints. Plumbers from the country mostly use thin cloths, and so make short thick joints, while metropolitan workmen use thick cloths and turn out long thin joints. For ordinary underhand-joint wiping ten to twelve folds are common; the folds are evenly and smoothly made and fastened at the corners, and the working face is saturated with melted tallow, to prevent the molten solder sticking to the cloth. Branch and upright joints require cloths of different shapes, the branch cloths are smaller, and the upright cloths are long, thick, and narrow. A separate bag must be kept for storing them, and no cloth should be used that is in any way burnt or torn on the working surface; neither should the cloths be saturated through with tallow, as they are then apt to get too hot for comfortable handling; many plumbers keep an oil-proof fold in the middle of their cloths to prevent this. The condition of a man's soldering-cloths is a good index of his skill as a solder-worker.

A strong pair of steel **compasses** and a pair of **callipers** are necessary, and three stout **chisels** of shear steel and of varied lengths and thickness, well forged, sharpened, and tempered; a set of six **steel points**, 12 in. long and ½ in. thick, will prove useful for fixing work temporarily in position in preparation for soldering.

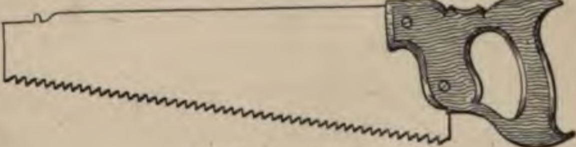


Fig. 26.—Plumber's Saw

The **plumber's saw** (fig. 26) should be of good material, about 20 in. long, with thin blade and small teeth widely set, and always kept sharp and clean; an occasional rub with tallow will ensure steel tools being kept clear of rust.

A screw-hammer (fig. 27) is used for screwing-up unions and back nuts on sanitary and other fittings. It should open its jaws at least 2½ in., to


Fig. 27.—Screw-hammer or Coach-wrench

take any size of ordinary fitting union. Other forms of grips and wrenches are in daily use by plumbers; the 6-in. and 12-in. grips are most convenient; these tools are light and yet strong, but in screwing-up finished or exposed work, it is best to muffle the jaws with a piece of cloth to prevent marks from the sharp teeth.

Plumbers' pliers are of two kinds, the large two-holed coupling pliers (fig. 28) and the flat cutting pliers.


Fig. 28.—Two-holed Pliers

Rasps and Files. — Rough- and fine-cut half-round rasps (fig. 29), with strong ash handles, are used for preparing lead pipe for joints, and for many other purposes in lead-working. The ordinary plumber's file is a 12-in. half-round bastard-cut file, though it is well to


Fig. 29.—Rasp

have also a small 6-in. file and a 12-in. three-cornered file. They are used in pipe-cutting and for the preparing and fitting of brass and other fittings. They should all have wooden handles and be of the best quality.


Fig. 30.—Snips or Shears

Snips or **shears** (fig. 30) are used for cutting lead, sheet-iron, zinc, or copper. They are made of best shear-steel, and should be moderately strong, accurately set, well tempered, and sharpened.

In setting out lead to dimensions for cutting up or working, no sharp tool, or metal edge of a rule, should be used to scratch the surface; all marks must be made with chalk, and all lines struck with a chalked line; this prevents unpleasant difficulties in bossing and dressing the lead in the position where it is fixed. A good cotton or hemp line, wound on a reel, is thus necessary.

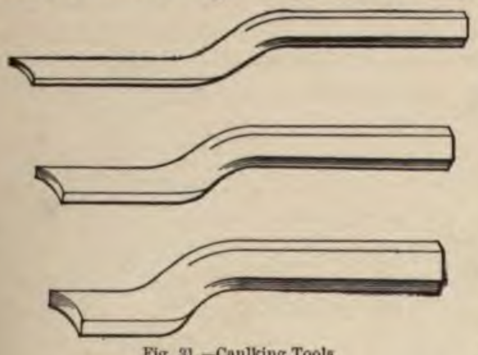


Fig. 31.—Caulking Tools

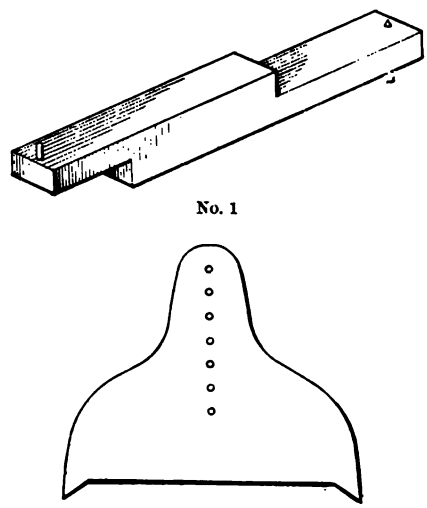
Caulking tools are used for jointing cast-iron pipes; they are made of forged steel, and are of various sizes and shapes to suit the position of the work they are used for. The yarner has a thin blade with the handle set off about an inch, so that it can be driven into the joint without injury to the fingers of the user; it is used for packing the yarn in the bottom of the joint.

The stavers are made shorter and thicker in the blade, and are used for caulking the lead which has been run into the joint, so that a water-tight joint can be obtained.

A **soil** or **smudge pot** of copper is required, together with a brush. The pot is circular in shape, 5 in. high by 3½ in. wide, with a wired edge, all the seams being welted. A wire bow handle is fixed at the top, the wire being carried across the pot for wiping or cleaning the brush used in applying the soil. A square of wire card cloth is used for cleaning the ends of pipes before coating them with soil.

The provision of a **looking-glass** does not imply that the plumber is vain and must always want to see his own reflection. The glass is generally about 4 in. by 5 in. square, enclosed in a wood case for protection, and is used for examining the surface of joints or other work fixed in corners, under floors, or in the roadway, where it is important that the plumber should see that no defects exist.

A **gauge** for soil- and waste-pipe work is made of hardwood (fig. 32, No. 1), and is about 10 in. long, and cut at one side to the length of soiling and at the other side and end to the length of cleaning for the joint. A sheet-brass gauge (No. 2) is used for branch joints. It is pyramidal in shape, the extreme points of the base projecting downwards, and holes are drilled in the sheet from the apex downwards. In use the projecting feet of the gauge are placed centrally over the hole for the branch. With a compass, using one of the holes as the centre, a semicircle is drawn on either side of the pipe, and the space inside is then shaved ready for soldering. By this means uniformity in the size and shape of the work is attained.



No. 1

No. 2

Fig. 32.—Hardwood and Brass Gauges

The Workshop.—A little consideration must be given to the equipment and arrangement of the plumber's workshop, so that whatever work is done there may be economically, conveniently, and skilfully carried out. The shop should be well lighted, preferably from the roof, with a concrete floor, a fireplace, and benches and tools of every description that may be needful.

The benches should be not less than 11 ft. long and 4 ft. wide, and not more than 3 ft. high, the top being of 2½ in. by 10 in. wrought deals, perfectly level and smooth, and supported on strong braced frame and legs. The edges at each side ought to be protected with 2-in. angle-iron fitted and fixed flush with the top. In shops where lead-work is a speciality, part of the bench is covered with a thick iron plate sunk flush with the top, so that the lead may be flapped and smoothed to a flat surface. In the

working of ornamental or fine bossed work, a thick baize cloth is sometimes used for protecting the lead from injury on the hard surface of the bench. In temporary workshops in new buildings, the plumber often finds it difficult to convince the general foreman that a good bench is necessary to produce good work expeditiously and cheaply, and has often to put up with very make-shift appliances, to the detriment of the quality and cost of the work, and also his own comfort. In every case he should insist on being provided with a good solid bench, so that lead soil- and waste-pipes may be properly prepared for fixing with all the necessary bends, sets, junctions, and lead supporting tacks. In reconstruction work the writer has always tried to get the kitchen for a shop, and the kitchen table as the basis for a bench, of course covering it over with boards to save it from injury.

Fig. 33. Plumber's Stove

The shop fireplace must be brick-built, with a strong iron front and bottom cast in one piece, the opening to be built up the exact size of the bottom, and a heavy iron bar built into the brickwork to support it at the front, while the back part rests on the brick-work; the height from the floor to be 16 in., and the opening above to be 2 ft. 6 in. A sheet-iron blower of the full size of the opening is suspended by a chain passed over two pulleys with a counter-balance weight, so that it can be readily moved up and down. A brick-built fender in front prevents any danger of fire. A pail filled with water should always stand beside the fire, for use in cooling the handles of irons or for extinguishing any fire that may occur. An iron bar is built into the walls across the opening, with **S**-hook attached to suspend the metal pot over the fire.

On outside jobs different fireplaces have to be used; the old-fashioned chauffer, or brazier, of sheet-iron, cylindrical in shape, with tripod legs, iron bow, and suspending hook, is seldom used for indoor work but is useful outdoors. When it is used, it should be placed in a sheet-iron pan containing a few inches of water. Another form of cast-iron stove (fig. 33) is rectangular in shape, with a small fire-box, double closing doors, fitted pot, damper, and smoke-flue pipe at the back, all standing on four legs; this also should stand in a pan of water. As plumbers' shops on new buildings are always reckoned dangerous, we should use every precaution to minimize the risk, and restore the public confidence. The large loose-brick fire on the open hearth should be avoided. The writer has seen two fires (fortunately not serious) arise from their use. If a temporary fireplace must be made, let it be in brick and mortar, with a good iron grate at the bottom, and a brick fender, and let the hearth be kept clear of ashes and rubbish.

A cast-iron heavy **copper** or **boiler** built in brickwork, with an ample

furnace, is used for melting lead for casting, or for manufacturing solder. This boiler should be fitted into a strong cast-iron ring, which would rest on the top of the brick furnace.

A set of cast-iron **tack-moulds** for soil-, waste-, and service-pipes is necessary. It is best to keep a stock of tacks ready in the shop in order to prevent delay on work in progress out-of-doors. They can be cast and trimmed in spare time that would otherwise be wasted.

Blow-lamps of various patterns are now often used for heating metal, and are very useful where it is inconvenient to have a fire. They are mostly of foreign manufacture, and burn ordinary paraffin-oil, which is vaporized by being passed through a heated burner, a hand-pump attached to the lamp giving the necessary pressure.

Hand-lamps are made of similar pattern, and are now extensively used for warming lead pipes in bending, and for assisting in the wiping of

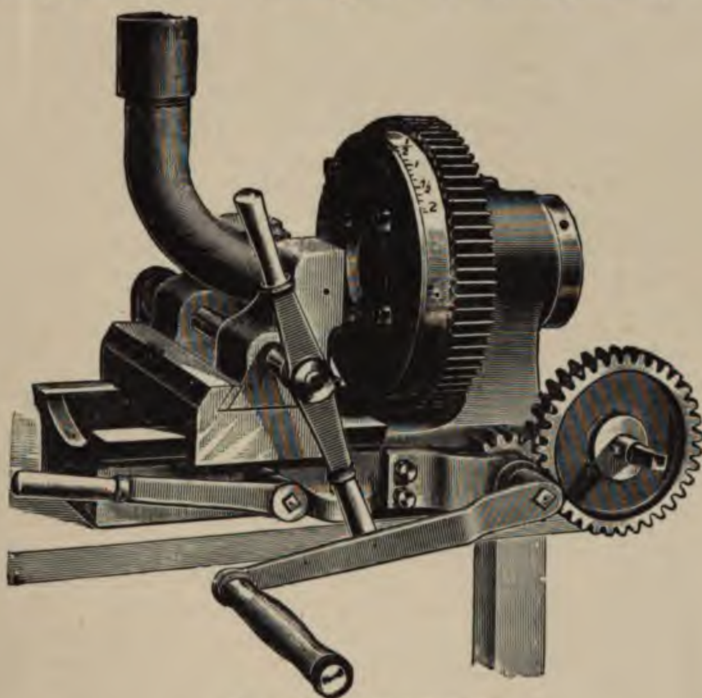


Fig. 34.—Pipe-screwing Machine

joints. Their use for the latter is not commended, as carelessness or accident may lead to fire. It is generally in awkward places that they are wanted for soldering, and when a man is engrossed in the joint-wiping, he does not always see where his lamp is blowing to, or where he sets it down. More than one fire has been caused in this way, and the writer is consequently of opinion that the lamp ought not to go beyond the bench.

A pipe-screwing machine (fig. 34) is a necessary tool in every shop. They are expensive but their cost is soon saved by their usefulness. They are simple in construction, wear well, and rarely get out of order. To each

tool a pipe-vice is attached, into which the pipe is fixed. The dies in the machine, which are generally in four parts on a circle, are adjusted to the size wanted, and by a rotary motion of a crank are run on to the end of the barrel, and the screw can then be cut with very little exertion, and unfailing accuracy. The machine has to be bolted fast to the end of the bench.

A set of mandrels for the larger sizes of pipes (from 2 in. to 6 in.) should be kept as shop-tools. They are made from oak or ash, straight-grained if possible, 3 ft. long, and the exact size of the internal diameter of the pipe, and rounded and slightly tapered at each end. They should not be allowed to lie about the shop, as they are easily damaged. A rack with a few hooks of hoop-iron fixed against a wall of the shop makes a good storage for them; they are thus away from dirt and grit, and ready for use when required. When preparing short lengths of lead waste-pipe for expansion-joints, expanding mandrels are used. These also are made of ash or oak, one-half the length of the mandrel being made the size of the pipe, the other half the size of the socket or faucet, and the central portion being tapered easily and smoothly to meet the two sizes. The ends should be rounded to enable the mandrel to be driven without injury to it or the pipe.

A steel-faced jack-plane is used for preparing and straightening the edges of lead to be soldered in cisterns or the undercloaks of lead-welted rolls, and for many purposes in shop work. A set of **large plumbing-irons** for use in cistern-soldering should be hung on a rack near the fire-place ready for use. A set of well-made **dummies** of varied lengths must be kept ready for use in the shop or for despatch to jobs where work is going on. They should not be allowed to lie about the shop, but should be kept in a rack easily accessible.

Fig. 35.—Pipe-vice

Vices. — An ordinary strong bench-vice is necessary for many little jobs that arise in jobbing and repairing work. A pipe-vice for iron barrel, sometimes called a "Samson" (fig. 35), must also have a place at one end of a shop-bench. This tool is made of a solid cast-iron block with a flange at the bottom, which is bolted to the bench. A circular opening near the bottom is formed, through which the pipe to be gripped is passed, and in the bottom of this opening is a fixed jaw with sharp-cut teeth forming the segment of a circle. The upper part of the casting is hollow, to receive a square block, to which is fixed a screw which passes through the top of the vice and is operated by a lever. The bottom of this movable block

is similar to the fixed jaw below. By turning the lever-handle at the top, the pipe is gripped between the jaws, and can thus be held fast while a screw-thread is put on the barrel or while this is cut to the length required.

Pipe-cutters are for iron barrel and are of varied patterns; one-wheel, three-wheel, and multiple-wheel are in common use.

The single-wheel cutter (fig. 36, No. 1) consists of a steel hook with a hollow shank, through which a spindle works by means of a screw operated by a lever handle. At the other end of the spindle is a sharp rotary wheel. The pipe is placed in the hook, and the spindle is screwed down till the wheel cuts into the surface of the pipe; by turning the cutter round the pipe, the wheel quickly cuts the metal.

The three-wheeled cutter (No. 2) is similar to this, but in addition to the wheel in the stock two wheels are fixed in the hook, so that it is only necessary to turn the cutter half round to cut the pipe off. This tool is very useful when the pipe has to be cut in position.

The multiple cutter (No. 3), which is principally used for cast-iron soil-, drain-, and rain-water pipes, consists of a series of steel links joined together, each link having a steel circular cutter fixed in it; the links are fixed at one end to a short handle. In use they are passed round the pipe, and the loose end linked to the handle; by means of a pinching-screw the links are pressed into the pipe, and the whole is rotated by the handle. As all the circular cutters run in the same groove, the operation of cutting a pipe is completed very quickly.

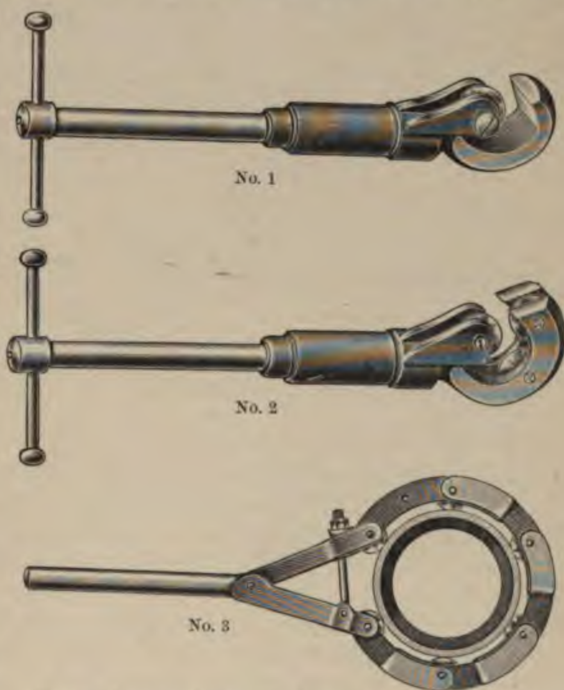
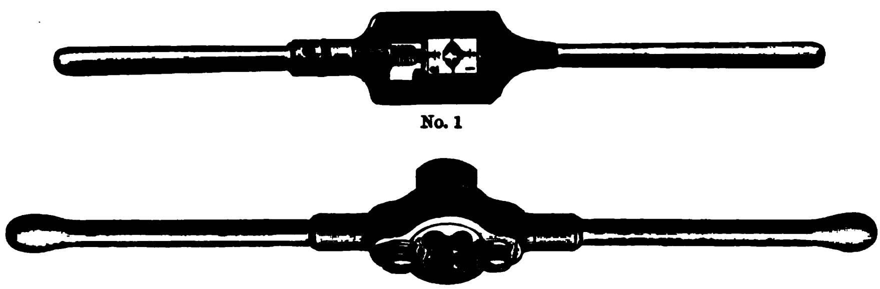


Fig. 36.—Iron-pipe Cutters: No. 1, Single-wheel; No. 2, Three-wheel; No. 3, Multiple-wheel.

Stocks and Dies.—A complete set of stocks and dies must find a place in every plumber's shop; the sizes required are from $\frac{1}{8}$ in. to 2 in., nine sizes in all—$\frac{1}{8}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. in one stock; $\frac{1}{2}$ in., $\frac{3}{4}$ in., and 1 in. in another; and $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., and 2 in. in a third. The old, or "ordinary", frame-dies (fig. 37, No 1) have a rectangular steel frame with extended arms. Into this frame two square steel dies are slipped and held in position by a strong pinching-screw. The inner or facing sides of the dies form segments of a circle, and are cut and screwed to the size and pitch

of the screw required. The pipe is gripped in the vice, the dies slipped over the barrel and pressed by the pinching-screw till the teeth cut into the metal, and the frame and dies are then turned round by the handles, and the screw is cut on the barrel, the operation being repeated till a full thread is secured. This form of die is very useful for some sorts of work, and at one time was the only pattern to be had. Its faults are a tendency to split the pipe when any extra pressure is put on it, its liability to make crooked threads, and the length of time required to cut a screw with it.

As all gas, water, and steam barrels are now made to standard sizes, a solid cutting die (No. 2) has been introduced, with a tapering thread



No. 1

No. 2

Fig. 37.—Stocks and Dies: No. 1, Ordinary; No. 2, Solid.

cut into many segments of a circle and provided with a guide, the whole fixed in a strong steel frame, to which are attached two movable handles (in the case of large pipes, four handles). With this a perfectly straight thread can be cut at one operation, and very rarely indeed is a pipe split. A set of these dies should be in every shop whose owner wishes his work to be done profitably. It is best to have a set of steel taps, a taper, and plug, for each size of die kept, and also a set of tap spanners, single and double handled. These tools must be well looked after if they are to be useful. They must always be cleaned and oiled after use, and when in use must be well lubricated, so that the dies or taps are not damaged by the heat generated in their working. It is best to keep them in a rack inside a case or box fitted to receive them, each tool having its own place in the box.

Pipe-tongs for all sizes of barrel should be kept, two pairs for each size, one for the socket and one for the pipe. They must be made to fit the exact standard size of the tube, the gripping-jaw to be steel-tipped, sharpened, and tempered, so as to grip the skin of the pipe and not injure it by flattening or splitting. If well made and fitted they are far better than many of the patent grips used, which under pressure frequently ruin the work they are meant to fix. Adjustable tongs are made, but are not as convenient in use as the ordinary kind.

CHAPTER II

SHEET-LEAD WORK

The Rolling-mill.—Before proceeding to describe the elementary details of work in sheet-lead, it will be useful to give a short description of the process of converting pig- or scrap-lead into the sheet as delivered to the plumber. Sheet-lead is either *milled* or *cast*, the former being now generally used. The rolling-mill (Plate II) is a long cast-iron frame of great strength, twice the length of an ordinary sheet, and of sufficient width to produce a sheet 7 to 8 ft. wide. The bed of the frame is formed of a series of small rollers placed crossways, and fitted at either end into the frame, so that they can easily revolve, the whole forming a moving table. In the centre of the frame two large steel rollers are placed; they are of great strength, polished on the surface, and hollow, so that they may be heated by steam. One is fixed in the frame so that its surface is level with the bed of the frame, and the other is placed in a strong grooved frame over the bottom roller, and controlled by screws, so that it can be raised or lowered at will very much like the rollers of an ordinary mangle. The whole is driven by a powerful engine. The lead, having been melted and cleaned, is cast into oblong blocks or cakes of sufficient size and thickness for the sheet required, and is placed, while still hot, on the frame, the engine started, and the lead, passing between the rollers, is squeezed out, gaining in length in the operation. The upper roller is screwed down closer, and the rolling repeated till the desired thickness is attained. The sheet is trimmed at the edges and rolled up, the length, weight per superficial foot, and the gross weight stamped on it. It is then ready for despatch to the customer. The ordinary sheet is generally 7 ft. by 34 ft., but larger sizes can be obtained.

Cast sheet-lead is sometimes used by plumbers, and occasionally they have to cast it for their own use. An opinion is held by many workmen that they cannot boss it as they do milled lead, and that it breaks in the working, so that a good job with it is an impossibility. This is partly true. If the lead is much alloyed, made from scrap, or cast too cold, it cannot be satisfactorily worked; but this is also true of much of the milled lead supplied. If the sheet is cast from pig-lead, or fairly clean metal, and care taken that the metal is properly mixed so as to secure a uniform heat, there is no special difficulty in working it into any form or shape. Its durability is certainly greater than milled lead, as proved by the time the lead has lasted on our old churches and cathedrals, most of which are covered with cast sheet-lead.

The appliances required for casting are a strong cast-iron lead-melting pot of sufficient capacity to hold 6 cwt. to 7 cwt. of lead (the pot being built into a suitable brick furnace), two large ladles, a special bench, a large sheet-iron tilting-pan, a similar receiving-pan on wheels, a quantity of moulding sand, a wooden strike, a copper planing-trowel, and a spirit-level.

The bench (fig. 38) is placed near the furnace, and clear access to it must be had all round. The top should be formed of closely-fitting cross boards, with rails along the two sides and at one end, raised 4 in. above the top; no rail to be fixed at the other end. The sand, after being passed through a sieve and damped, is spread over the bench-top, to form a bed about $1\frac{1}{2}$ in. deep. This is done by means of the strike, A, a piece of wood that fits between the side rails of the bench, and has two projecting handles, which rest on the rails. The strike is passed backwards and forwards on the sand till this is fairly packed and quite level; the strike is then removed, and wiped clean and dry. The sand bed is now smoothed over and polished with a square copper trowel, the edges being slightly rounded upwards to prevent digging into the sand, and the surface of the tool rubbed with tallow: by these means a smooth flat surface is secured. The tilting-pan, B,

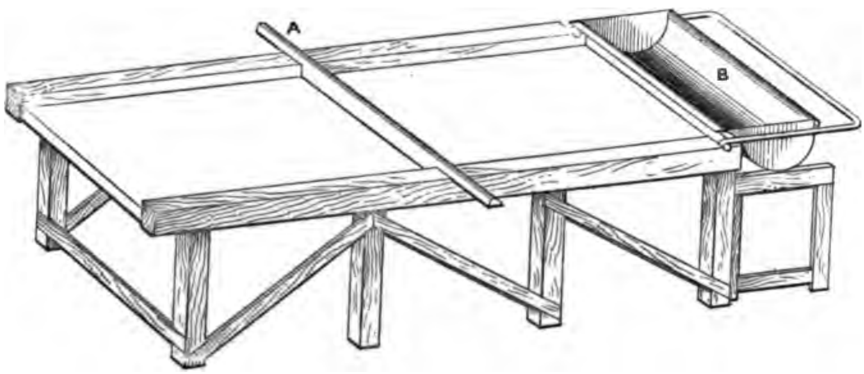


Fig. 38.—Bench and Tilting-pan for Casting Sheet-lead

is semicircular in shape, and of the same width as the sand bed, and is furnished with trunnions at the front edge, which rest in grooves cut into the end of the side rails. the inner lip of the pan projecting over the end rail of the bench. The body of the pan rests on a pair of folding trestles attached to the end of the bench, so that when in position the top is level with the bench rail. The pan on wheels is of similar shape, and is placed on the floor under the open end of the bench. The spirit-level is applied to the rails and sand bed to ensure the accuracy of the latter, and leather bands of the thickness of the sheet to be cast are attached to the handles of the strike, so that when this is laid on the rails a space of the same thickness will appear between the bottom of the strike and the sand bed. The melted lead is quickly placed in the pan, by means of the two large ladles, in sufficient quantity for the sheet; it is well stirred and mixed, so that it may be uniform in heat. The strike is held ready by two men, one at each side, and a third man tilts the pan and pours its contents on to the sand bed, along which it runs in a broad stream; the strike is pushed quickly along the rails, driving the surplus metal in front, till it drops into the pan placed to receive it. A knife is quickly drawn across the sheet an inch or so from the end, cutting right through the hot metal. This allows it to contract in cooling without cracking. The surplus metal is taken back to the pot, the new sheet rolled up, and the sand prepared for another cast.

Care in Transport.—Rolls of sheet-lead are of considerable weight, and require a good deal of strength to move them about. Accidents in transport lead to a great amount of extra work and consequent loss; thus, if a roll is carelessly slipped down a skid from a van, and allowed to bump heavily on the ground, the end may be flattened, and sometimes the roll may be bent, and, if the ground is rough, the outer folds may be cut and bruised, so that they have to be cut off and thrown on the scrap-heap.

Unloading.—In plumbers' premises where lead is stored, the rolls ought to be unloaded by a small derrick crane with chain slings and sheet hooks, a small two-wheeled trolly being used to take them to the place where they are to lie. For use in moving sheets about, it is necessary to have the following appliances:—A small but strong two-wheeled trolly, two strong tough wooden handspikes, two strong cross-handled sheet hooks, four 3-in. hardwood rollers (mandrels ought not to be used for this purpose), and two or three iron crowbars; with these, in the absence of a derrick, the sheets may be moved without injury to them, and without any excessive exertion.

The floor where the sheets are to be cut up should be as level as possible, and may be of deal boards, asphalt, or cement-concrete, swept clean, and large enough to allow a full sheet to be unrolled.

The Cutting of Lead.—When practicable, it is best and most economical to have all lead cut out at the shop or yard. The plumber's foreman can go on the job and take exact descriptions and sizes of the lead required, and with the assistance of a couple of men have it cut out under his own supervision, thereby avoiding the damage to and waste of material often incurred when work is done under difficulties in a new building. After the sheet has been completely unrolled and flattened out where creased, mark out the whole surface at once with chalk to the various sizes, so that one piece may fit into the other, so as to cover the surface without waste. Chalk-lines are struck from mark to mark, and show exactly where the lead must be cut. Then the foreman takes the long-handled draw-knife, to which is attached a strong rope and wooden handle, and presses it well into the surface of the lead at the chalk-mark, guiding it while it is drawn along the sheet by the men with the rope. With a pocket-knife the outer edge of the lead is cut through; the lead easily tears along the cut made by the draw-knife, and each piece is at once neatly rolled up, the size, description, and destination being marked in chalk on the inside of the outer fold of the roll, so that it may be readily picked out by the workmen on arrival at the job.

In cutting out lead to patterns and sizes, avoid cutting into the centre of the sheet, or cutting up each side, leaving a tongue or strip in the middle. If possible leave the sheet in such a way that it can be subsequently used without having to cut off useless ends.

Lead for flats is cut into bays or sheets, a 7-ft. sheet being as a rule halved for the width; the length is determined by the construction of the roof. Valleys and ridges are cut in 7-ft. lengths across the sheet; dormer cheeks are generally triangular, and can be cut into each other, and tapered gutters can be similarly dealt with; flashings (step and plain) are cut in

7-ft. lengths. By arrangement with the carpenter, when framing the roof, many other parts of the lead for the roof can be made to fit into the sheet with the minimum of waste both of time and material.

Lead-work on Roofs.—It is important that the plumber's and carpenter's foremen should be in close touch when the roof of the building is being worked out in detail. There are certain rules of construction that are essential to the success of the work. All gutters should be laid with narrow boards, closely jointed and well nailed to supporting brackets or bearers, the joints planed quite level, and the lowest or outlet end not less than 10 in. wide; drips (fig. 39) should be $2\frac{1}{2}$ in. or 3 in. deep, and not more than 8 ft. or 10 ft. apart, and a fall of 2 in. in 10 ft. should be allowed along the whole length of the gutter. It is a good plan to cut grooves, A, in the drips to stop capillary attraction. In the north of England and in Scotland it is customary to have deeper drips in gutters than in the south. A 2-in. drip is the usual size in London, with the under-lead turned over the drip and nailed, and the overcloak lead dressed and trimmed on to the flat, as in No. 1. The same method is used for covering rolls. With a 3-in. or $3\frac{1}{2}$-in. drip the northern plumber turns the lead up the face of the drip, and trims it a quarter of an inch from the top; the over-lead in the drip (No. 2) is cut off half an inch from the sole of the gutter, and by this means capillary action is avoided and the accumulation of dirt and rubbish under the flat lead prevented. In the case of rolls the overcloak lead is trimmed off in one of the ways shown in fig. 52. Cesspools at the ends of gutters should be 6 in. deep by 10 in. wide by 10 to 14 in. long.

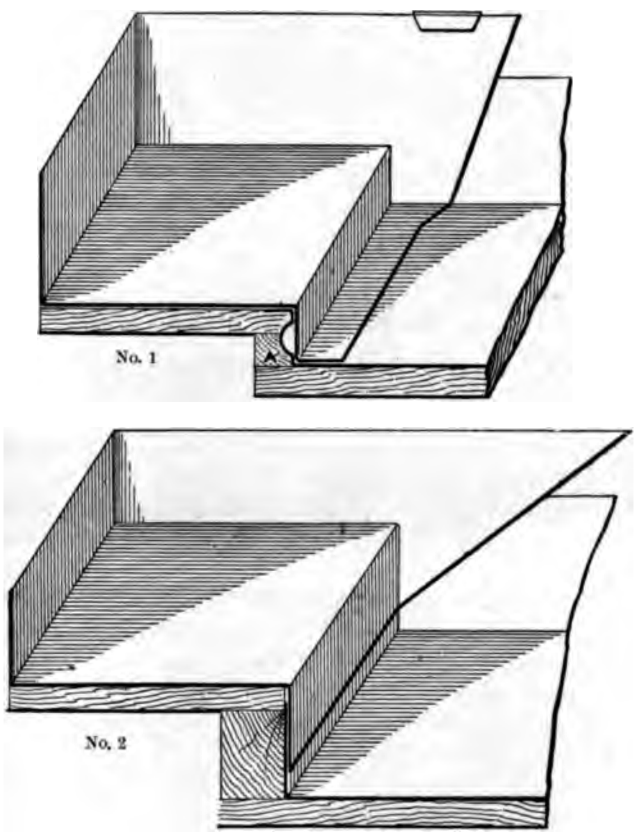


Fig. 39.—Drips in Lead Gutters

Flats ought to have a minimum fall of $1\frac{1}{2}$ in. in 10 ft., and to be formed with narrow close-fitting boards laid lengthways with the fall; all arrises

to be planed down so that the lead may not be injured by sharp angles and raised joints when it is expanding and contracting with the varying temperature. The front of the flat, where it joins the sloping roof, should have a bold torus roll, as this improves the appearance and enables the plumber to get a fixing for the front flashing, and also helps to tie down the lead and keep it from being blown off during high winds. Ridge- and hip-rolls must be fixed on the roof sufficiently high to allow for the thickness of the slates or tiles and battens on the roof boarding.

The cesspool, being the lowest part of the gutter, is first lined, and all the laps and drips are worked towards it. The plumber unrolls the piece of lead on the roof or on his temporary bench, and proceeds to take out all the dents and creases with a soft-wood dresser. This looks easy to the onlooker, but really requires considerable skill, as the edges and ends of the dresser are apt to strike and mark the lead, making it very difficult to work or boss. The beginner finds that he must exercise great care as well as patience before he can acquire the necessary ability to wield the tool with the easy swing and unerring accuracy of the skilful workman.

Working up a Cesspool.—If the cesspool is to be worked up, he proceeds to set out the dimensions of the bottom and sides with chalk lines, the lead being divided into nine spaces (fig. 40), the one in the centre, A B C D, being the size of the bottom, the four spaces surrounding and projecting from the bottom are the sides, and the four corner squares are the surplus lead that has to be worked up to form the angles. Some plumbers use all this lead to work up the angles, but as this entails considerably more work than is necessary, it is best to cut a portion of it away. Set the compasses to a radius equal to the breadth of the square, and, using the outer corner of the lead as a centre, describe a quadrant. Cut this out with a clean continuous action, so that there are no jags in the edge; then, with the edge of a dresser, mark the lead along the bottom lines, fold up the sides, and dress them square with the bottom (fig. 41), using a block of wood on the inside and a dresser on the outside. This will leave a projecting lug at each corner. Turn the lead over, and with the dresser and mallet mark-in a stiffening crease, *a b c d* (fig. 40), all round the bottom, about 1½ in. from the angles; this prevents the lead from dragging out of the corner when it is being wrought.

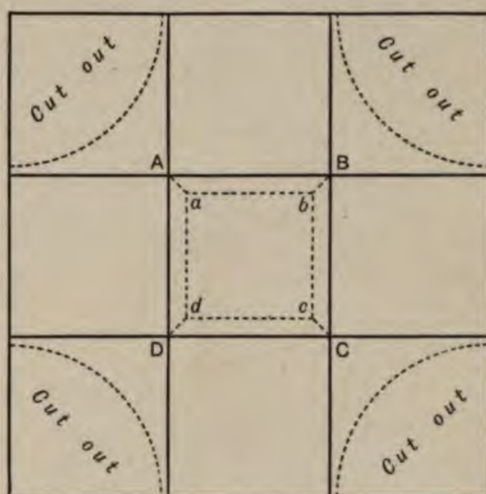


Fig. 40.—Method of setting-out the Lead for a Cesspool

To work up a corner is about the first job in lead-work that is give the beginner, and a difficult job he finds it. Turn the lead box on its

first seeing that the sides are correctly set in and bent to the angle required. Slightly round the lugs; then put the left hand inside the corner, the middle finger pressing right into the angle, and with the bossing dresser in the right hand give a few smart taps to the lug close to the angle. This is intended to drive the metal backwards, and so form the beginning of the angle; every blow should be felt by the finger in the inside. Having got the corner started, proceed to work the lug upwards, keeping the sides at the correct angle with the bottom. Do not try to hurry or rush the work, but see that the blows on the lead are given fairly and in the right direction; that is to say, upwards and inwards. The lead must be worked evenly and smoothly in a circular form, no buckles or creases being allowed to form, and the lug that looked so small at first will travel up till it has got above the corner, and can be cut off. This is repeated at each corner, so that a lead box or cesspool is formed without seam and of uniform thickness. For a photograph showing the work in progress, see Plate VII.

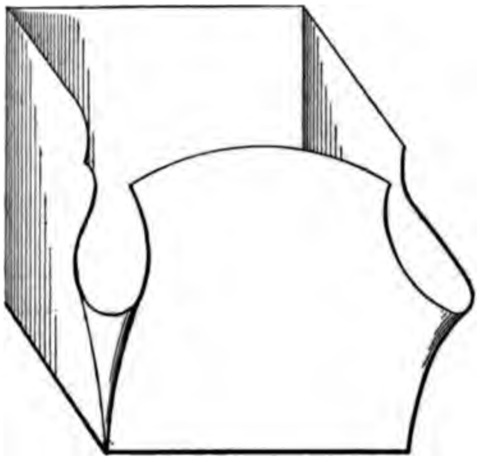


Fig. 41.—Cesspool partly worked

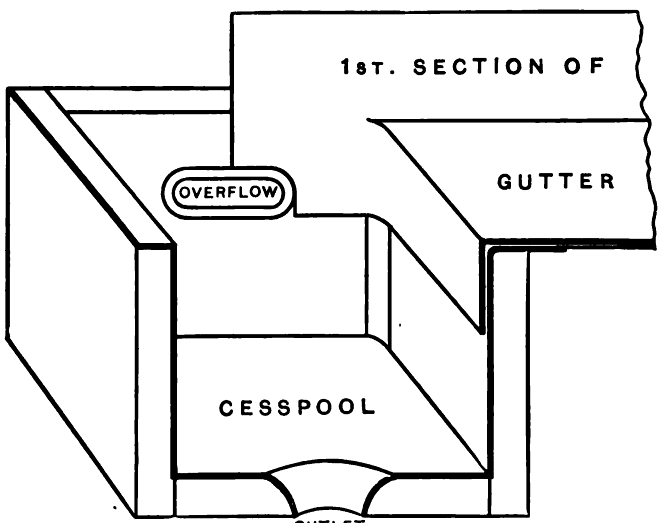
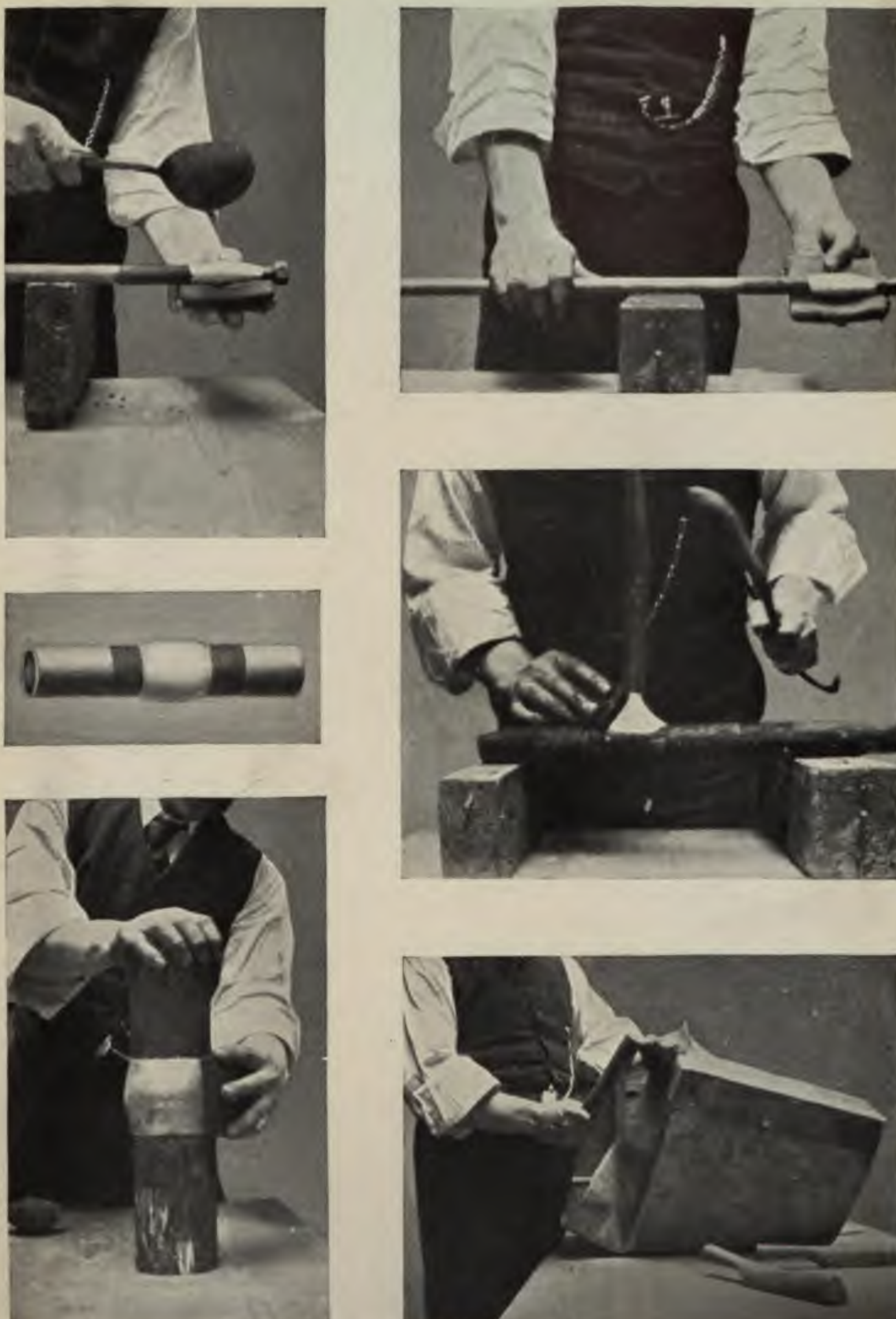


Fig. 42.—Cesspool in Position with Outlet and Overflow

In using a bossing dresser, see that it is smooth, and always use the face or side of the tool, and avoid punching with the end. While working up the angle, the sides are apt to spread out; if this is allowed the lug left

PLATE VII



WIPED-JOINT MAKING AND LEAD-BOSSING

on the angle will not be long enough to fill up the corner. A plumber should thoroughly master the art of bossing a simple corner, as it is the alphabet of lead-bossing and the key to many a difficult job. A good test of efficiency is to take a piece of lead the exact size of the square of metal in the corner, and weigh it against the semicircular piece cut out and the surplus cut off the corner after working it up; if they are of nearly equal weight, it proves that the work has been evenly and correctly done.

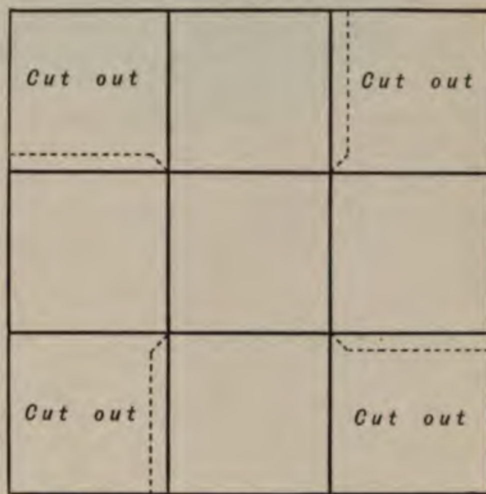


Fig. 43.—Method of setting-out the Lead for a Cesspool with Soldered Seams

The cesspool is then placed in the box prepared for it (fig. 42), the creases dressed out, and the lead worked through the outlet-hole in the bottom ready to receive the down-pipe. It is not necessary to nail the lead in any way, as freedom must be given for expansion and contraction.

Some plumbers leave the whole of the lead in the corners, and with a dummy held inside use a mallet to gather the surplus lead; they thus give themselves a great deal of unnecessary labour, and do not produce as good a job as can be obtained with the plain bossing dresser and the hand.

Soldered Cesspools.—Cesspools with soldered corners are specified by some architects as being stronger and easier of execution. The lead is set out as in fig. 43, and cut at the dotted lines. The edges of the angles are prepared for soldering, the lead folded and lapped at the corners, and a soldered seam is then wiped in each angle, forming a box with rigid seams.

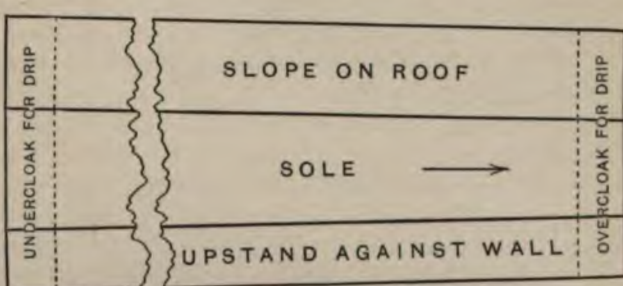


Fig. 44.—Setting-out the Lead for a Gutter

The Gutter (First Section).—The lead for the first section of the gutter is rolled out and similarly dressed, the upstand against the boundary wall (generally 6 in.) is marked on the sheet, and also the breadth of the sole or bottom (fig. 44). With a bevel the exact angle of the drip is taken, and marked on the upper end of the sheet, 4[illegible] for the drip. A chalk mark is struck at these dime[illegible]'s allowed along one side of the sole to extend up [illegible]ght of

6 in., and 6 in. is allowed for working into the cesspool. A fillet of wood, locally known as "springing" or "doubling", is nailed on the slope of the roof along the whole length of the gutter and about 5 in. from the sole, for the purpose of tilting the slating so as to make the under-eaves firm. The plumber, with a setting-in stick of soft wood and a mallet, marks the lead at the chalk lines, and with a straight-edged piece of quartering, placed on the line to kneel on, he and his mate pull the lead up, and dress it against the timber. This is repeated at the other side and at the drip. The quartering is then removed and the angles again set in and carefully dressed, inside and out, to the shape required.

For convenience in working up the corners of the drip, the gutter is folded across about 2 ft. from the end (fig. 45), and held in this position by the mate. The plumber, with a dresser, makes a stiffening crease on the under side near the corners of the drip, and proceeds to work them up to the height of the drip.

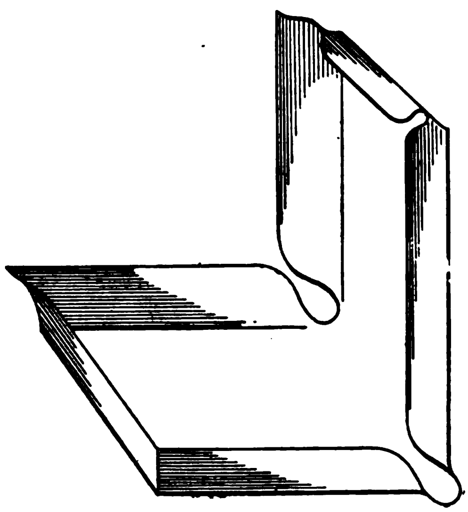


Fig. 45.—Method of working a Drip

The gutter is then placed in position and dressed flat on the sole, the angles at the wall and the junction of the roof being set-in solid. The lead is dressed and folded over the springing fillet, and on to the roof beyond; the drip is set-in with a soft-wood chase-wedge, the crease driven into the angle and set-in to the capillary groove, and the surplus metal folded over the end of the next section of gutter, which is recessed to receive it; a few copper nails are sometimes driven into this fold to keep it in position. A bead is formed on the end of the upstand, terminating at the drip, to form a check or water-bar against driving rain.

In working the end of the gutter into the cesspool, the lead projecting beyond the sole is bent over the end; this doubles the upstands on either side till they almost meet in the centre of the gutter. The lead sole is held down while the upstands are gently worked back to their place, the metal being drawn from the sides into the face of the drip. This has to be carefully done, so that the metal is worked to a uniform thickness throughout. This operation of folding over the lead and working it down is repeated till it is squarely and evenly brought into position (fig. 42). While this is in progress the sole of the gutter is apt to bulge up and buckle; this must be carefully guarded against, and every appearance of rising or buckling at once dressed down with a soft and blunt-edged dresser or a lead-flapper.

Lead in gutters should not be nailed or fastened in any way that would prevent its expanding or contracting freely with the varying temperature. Slaters and tilers are great offenders in this, as frequently they nail their

under-eaves course through the lead. This prevents it moving freely, and causes cracks and leakages.

The Gutter (Second Section).—The second section of gutter is then unrolled and marked off with the various lines as before. A portion of the brick wall may pro-

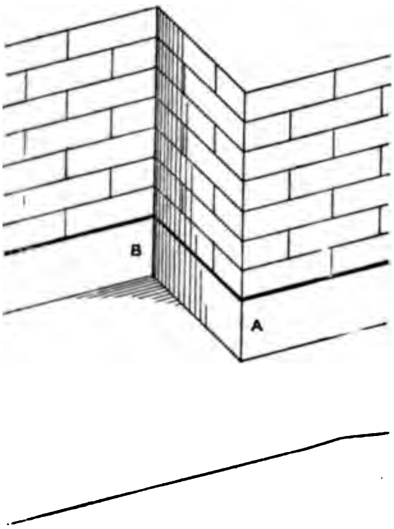


Fig. 46.—" Break " in Gutter

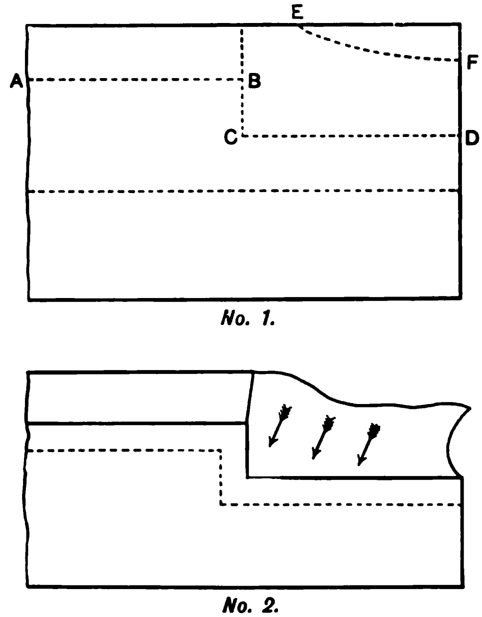


Fig. 47.—Setting-out and working the Lead for a Break

ject into the gutter, forming an obstruction or " break ", around which the lead has to be fitted. A break of this kind is shown in fig. 46, the angle at A being known as an internal angle or " break ", and that at B as an external angle or "corner". The lead would be cut as in fig. 47, the dotted lines A B C D showing the position of the finished angle formed by the sole and upstand. In working this, the material has to be drawn from the outside edge into the internal angle. In working an external angle the lead must be dressed inwards and upwards, and a surplus has to be got rid of, but in an internal angle the metal has to

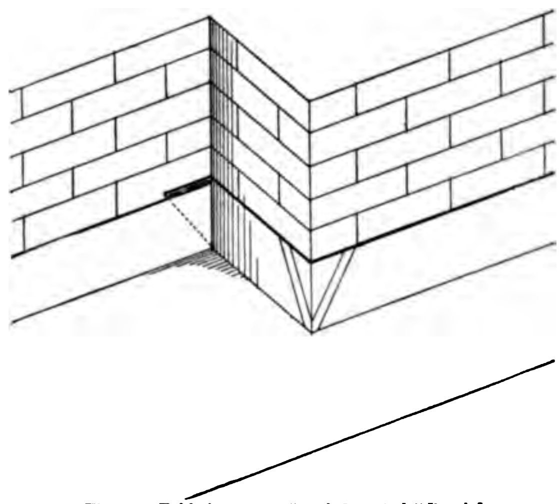


Fig. 48.—Folded " Corner " and Gusseted " Break "

be gathered-in to fill up a place where it is wanting. Some plumbers, instead of working up the two angles, fold and dog-ear the outside one, and cut the inside one and fill the vacant space with a gusset of sheet-lead (fig. 48),

which is joined to the main sheet with solder, either wiped or copper-bitted. This is not a creditable way of doing the work.

To set out a break, mark on the sheet the position of the obstruction, and allow for the upstands. Fold the lead at the angle next the wall (fig. 47, No. 2), set-in the lines of the break, and turn the sheet over on its side; then set-in a stiffening crease 2 in. from the break-angle, and proceed to work-in the outside corner, driving the surplus lead towards the break. Cut away a portion of the material not needed (E F, No. 1), and with quick strokes, evenly and sharply delivered, dress the lead inwards towards the break, keeping it in a round shape so that each blow is given on the outside of a circle, and, while driving the lead, does not unduly distress it. The break is apt to become distorted while this is being done, so that it requires to be bent into shape frequently. The best tools to use are a smooth-faced bossing-stick and a small round-faced mallet, and the beginner must not try to hurry the work, as four or five blows wrongly applied will sometimes spoil the job. Avoid unnecessary working of the material, and be careful not to mark or crease it. Do not allow it to get into thick hard lumps, or into furrows of thick and thin lead; the metal should be evenly worked or (as the Scotch plumbers say) "forged" to an equal thickness in every part.

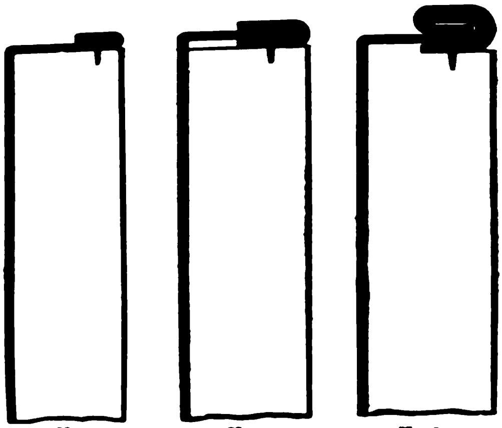


Fig. 49.—Vertical Angles of Dormer-cheeks

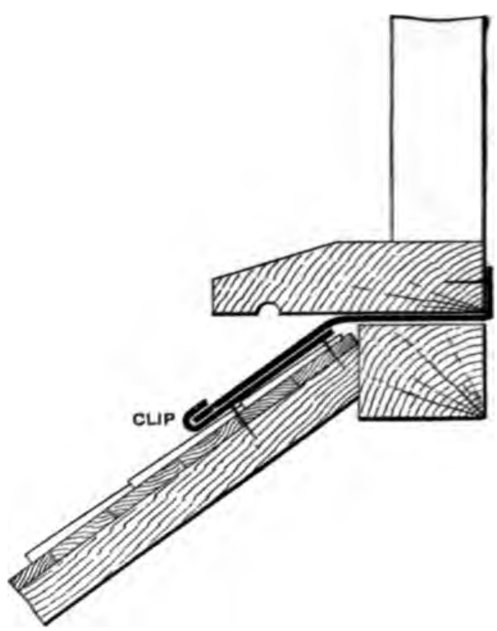


Fig. 50.—Lead Apron under Sill of Dormer

The foregoing advice applies to all forms of lead-bossing; lead is a tractable metal and can be coaxed into any shape, but any attempt to force it will result in failure.

Nailing Lead.—Lead is sometimes used in such positions that nails are required to fix it. These nails should always be of copper, and should be used only where they are not exposed to the sun's rays. In

fixing dormer-cheeks where the lead finishes at the window-frame, the lead may be close-nailed, and the outside edge folded over, so as to cover the nail-heads (fig. 49, No. 1), or a separate strip of lead (Nos. 2 and 3) may be nailed along one edge into a rebate (cut in the wood to receive it), and the other edge be folded to overlap the edge of the cheek-lead, the latter being thus free to expand and contract. At the tops, where the cheek and the flat are joined, the cheek can be close-nailed, the top lead folded and welted together and so dressed over the nail-heads. Where lead sills or "aprons" are fixed under dormer window-frames (fig. 50) the inner edge of the lead should be close-nailed where it is folded against the inside of the sill, and the outer edge may be supported by clips as shown. In no case is it right to use nails for fixing lead that is directly exposed to the sun's rays.

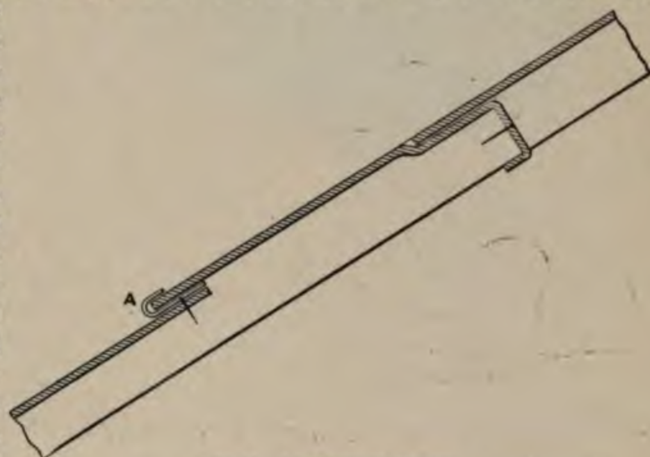


Fig. 51.—Lead Laps or Passings

Methods of Joining Lead.—The methods of joining sheet-lead together are: laps or passings, welts, rolls (wooden and hollow), drips. soldering, and

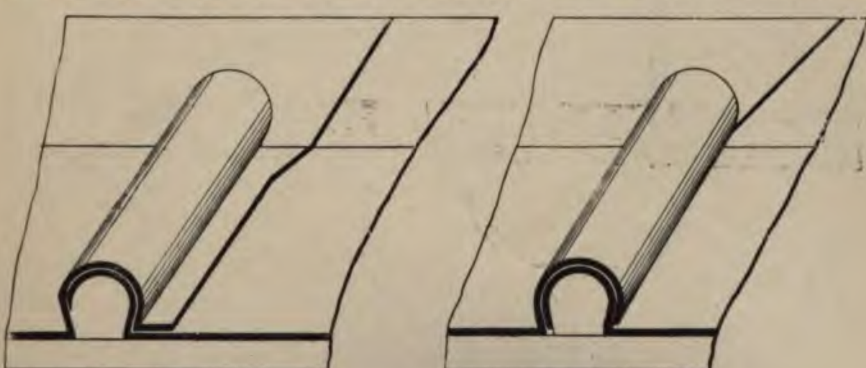


Fig. 52.—Rolls for Lead Flats

seams. Where the material is laid at a fairly steep declivity, as on a pitched roof, a lead pass of 4 in. cover is su[illegible] is kept from slipping by thin sheet-copper tacks (A, fi[illegible] and nailed to the roof. The tacks fold or welt ove[illegible] [illegible]per lead, and thus support it, while leaving it f[illegible]

For flats, *wooden rolls* (fig. 52) [illegible] [illegible]t the

bottom. The undercloak of lead is folded up and dressed over the roll, the edge shaved off (so that the bed for the overcloak is left smooth) and copper-nailed along the whole length. The overcloak is then turned up and dressed over the roll, set closely into the angles, and trimmed off as shown in Nos. 1 and 2, No. 1 having a margin of 1¼ in. on the flat. The lower end of the roll is worked over so that it grips tight; the upper end is folded and bossed into the angle, a blunt chase-wedge and mallet being used for this, and a rounded steel plate (A, fig. 53) laid on the undercloak to protect it while the overcloak is driven into the angle.

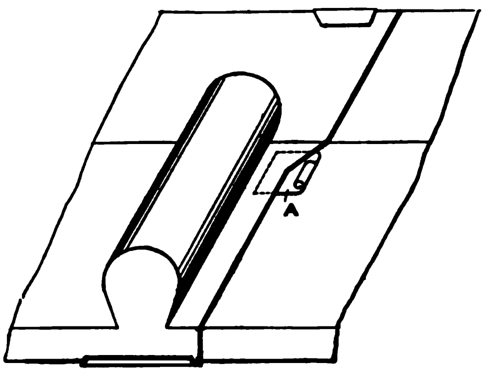


Fig. 53.—Ends of Roll

Hollow seams or rolls (fig. 54) are used on church roofs, towers, and (in many parts of the country) on lead flats. They are the best form of roll where there is no traffic on them, as the lead is not in any way bound in their formation, but is free to expand and contract. The undercloak is 2½ in. wide and the overcloak 3½ in.; these are set-up close together (No. 1)

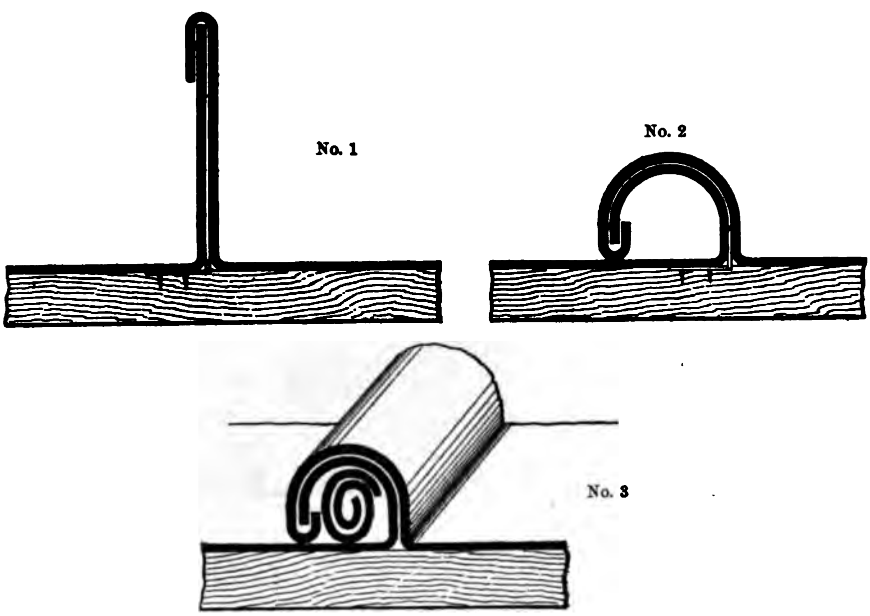


Fig. 54.—Seam-rolls

and dressed quite flat, and the lap of the overcloak is folded over the undercloak and dressed perfectly close between two dressers. The edge of the welted lead is then slightly hollowed with a round-faced dresser, and is dressed over in the form of a hollow roll (No. 2). The lower end of the

roll is filled with a lead plug (No. 3), and bent over the nosing and kept in position with a hollow-faced dresser. The upper end of the roll is worked up in position, so that the seam runs into the upstand, forming a flat welt against the wall or drip.

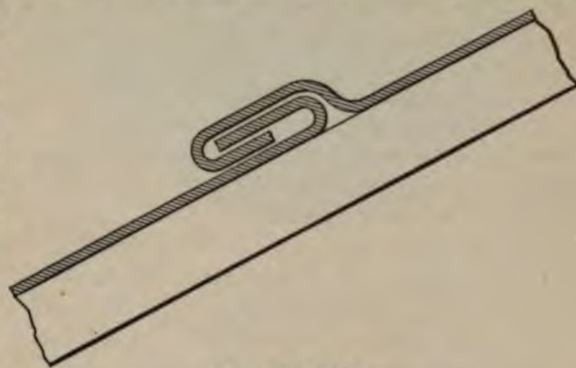


Fig. 55.—Welted Seam

Welted seams (fig. 55) are made somewhat similarly, but instead of being hollow are clenched close together, and so require less material. They are used principally on upright work, as in dormer-cheeks and roof bulk-heads, and lead-covered gables. Thin sheet-copper tacks are screwed to the wood-work under the sheets and folded into the seams, forming excellent fixing and yet leaving the lead quite free to expand. Similar tacks are fixed at the bottom, the copper being screwed in to the boards and bent like a hook under the bottom edge of the sheet.

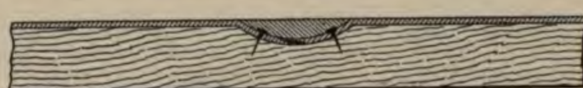
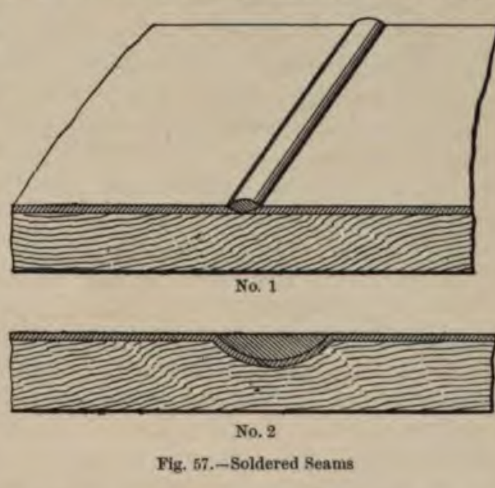


Fig. 56.—Soldered Dot

Soldered dots (fig. 56) are sometimes used to fix lead on the upright. A circular hollow is cut in the boarding, about 3 in. in diameter and ½ in. deep, into which the lead is dressed, and two or more screws, with copper washers under the heads, are screwed through the lead diagonally into the wood. The hollow is prepared for soldering, and a patch wiped over the screws and washers forming a very rigid fixing. This method of fixing is very undesirable; if the sun has much play on its surface the lead is liable to crack and tear away round the edge of the solder. Small welted sheets, with copper tacks in the welts, are far better. Patches of bright solder and black soil-marking are not beauty-spots on a piece of finished lead-work.



No. 1

No. 2

Fig. 57.—Soldered Seams

Lead is sometimes joined together by *soldered seams* (fig. 57). There are two ways of making these, one with the copper soldering-tool, the other with the molten metal wiped with a fustian cloth. For copper [illegible] the hatchet-shaped bit

is most convenient. A stick of "fine" solder and a dish of powdered resin, with a fine-cut rasp and a sharp shave-hook are necessary. The lead to be joined must be perfectly straight, and dressed out flat on a level piece of board. The edges are bevelled off about $\frac{1}{4}$ in. with the rasp, so that when placed edge to edge a V-shaped channel is formed (No. 1); the lead is soiled on both sides and dried; the bevelled edges are shaved clean and rubbed over with tallow to prevent oxidation, and placed again close together on the board. Powdered resin is then dusted in the groove. The copper-bit, heated to the proper temperature and tinned on the bottom edge, is then used to tack the seam every few inches, so that it may not change shape or open at the joint when a continuous heat is applied to the work. The resin is again applied to the joint, and, commencing at one end, the strip is melted into the groove, the bit being moved backwards and forwards until the resin flux is floated out of the joint and the solder adheres to and unites with the lead. After quite filling the groove with solder, another dusting of the resin is applied, and the bit is drawn along the seam, melting the solder throughout. If this is done carefully and steadily, and the lead is quite level, a raised seam like a smooth cord will be left behind the tool. A piece of tallow rubbed on it while hot enables the resin flux to be wiped off clean, and so leaves a neat joint.

The *wiped joint* is used in cistern-lining, in making up lead heads, and occasionally in the angles of cesspool boxes, &c. The lead is prepared as above, the edges, however, being generally made to overlap. If in a gutter or on a flat, a hollowed groove (fig. 57, No. 2) should be cut in the woodwork of the roof, 2 in. wide and $\frac{3}{8}$ in. deep, throughout the whole length of the seam. The lead is dressed into this, overlapped at the junction, and shaved clean in the channel, and the surrounding lead coated with soil. Tallow is rubbed over the shaved surface. The solder is melted in a stout metal pot and poured into the joint from a small ladle, which must be kept moving backwards and forwards (so that the solder gradually heats the whole seam) till the metal has thoroughly tinned on to the lead. When all is sufficiently hot, the ladle is laid aside, and a cloth of folded moleskin, well greased on the surface, is used, first for patting the hot metal into the seam and clearing away the cold solder, and then (with a quick deft action) for wiping off the surplus metal, leaving the joint flush with the lead on either side. If the seam is long, a plumber's iron is used to keep the solder at the required heat.

In soldering the angles of cisterns and cesspools the lead is lapped at the junction (fig. 58, No. 1), the surface of the sheet well soiled, and the seam shaved clean to a width of $1\frac{1}{2}$ in. from the angle, so that when soldered a fillet of metal is left in the corner forming a strong smooth seam and a water-tight joint. Cloths for use in lead-wiping should be thick and not too large, so that the joint may not be left hollow when wiping on the flat, or too thin in the angles of cisterns or cesspools.

The ordinary way of *soldering a cistern* is to line the two sides and the bottom in one piece, and fit in the ends with the edges lapped over the sides. The cistern is turned on one end (fig. 58, No. 2), with the opening facing the workman and the seam quite flat. The solder is poured on to the seam

at the right-hand side by means of a hollowed piece of wood held under the ladle, and moved backwards and forwards, heating and tinning the shaved lead equally along the side; the metal is pushed with the cloth into the angle in sufficient quantity for filling the complete seam round the bottom and sides. A large plumbing-iron, heated to a red heat, is passed along the melted metal, and with the cloth the surplus solder is pushed along the seam. The angle is wiped forwards to the outside edge for some distance inwards; then the cloth is pushed along the seam right into the corner, wiping a clean smooth seam. The remaining metal is gathered along the seam at the bottom, and heated again with the iron until it is thoroughly tinned; while still hot the corner is wiped out, care being taken that no metal is left beyond the cleaning of the seam. This process is repeated till the seam all round has been completed. To ensure good work the metal should not be too hot, the irons must be perfectly clean, and the cloth of the proper thickness. When wiping, take as long a sweep as possible at each operation, so that the seam may be quite smooth and even, and without the appearance of joints or patches.

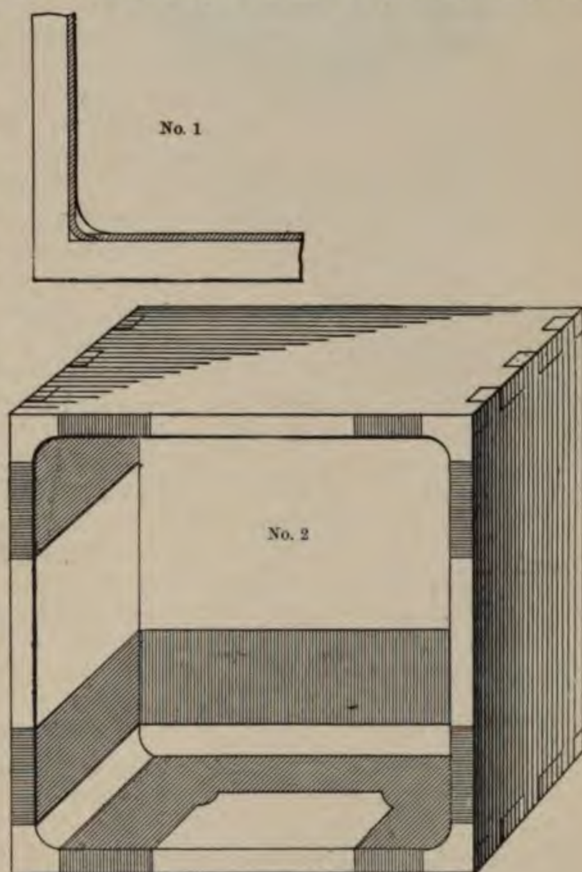


Fig. 58.—Soldered Angles of Cistern

Sheet-lead is also joined by means of *burning*. The edges of the lead are overlapped half an inch and the metal fused together with a powerful gas-flame projected through a blow-pipe, and operated with a small bellows. This joint is made without solder, and is used principally for to store strong acids. The operation of lead-burning, and required, will be described in Chapter VII.

CHAPTER III

LEAD-PIPE WORK

Old Lead Pipes.—Explorations in ancient cities have shown us that lead pipes were at a very early period used for the conveyance and distribution of water for domestic purposes. The specimens that have been discovered amongst these ruins show that the craft of the plumber was an important one, and that considerable skill had been attained in it. It appears that the first pipes were made from strips of cast sheet-lead, turned into a circular shape and soldered along the side or seam. At a later period pipes were cast in lengths of varied thicknesses, and in many of the older houses in London such pipes are still to be met with. The specimens which the writer has seen were not very pliable, and fractured readily when bent. He has cut out some pieces of pipes, cast in this way, which had been in constant use from the sixteenth century. They were very uneven in thickness, and could never have been easily bent.

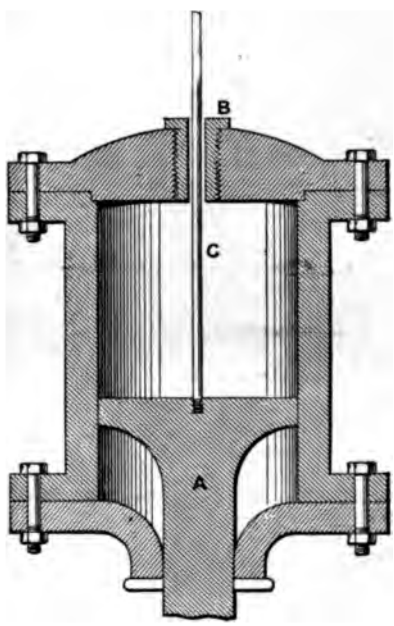


Fig. 59.—Press for making Lead Pipes

Drawn-lead Pipes.—The introduction of hydraulic machinery revolutionized the method of manufacture. By means of hydraulic pressure, applied to a piston (A, fig. 59), heated lead is forced from a vessel through an annular orifice formed by a circular steel gauge, B, and a steel core, C. The pipe thus formed may be drawn out to any convenient length, and the metal is of uniform thickness. For a long time this method of manufacture was confined to service-pipes and very thick pipes of larger bore, and also to the making of tinned "compo" pipes for gas-fitters. The pipes used for waste and soil, being much thinner, were still made from milled sheet-lead and soldered at the side, and all the bends and off-sets for these were made up in two halves and soldered together. Traps of all sizes were made in the same way. Now, however, improvements in machinery have entirely done away with this work, all pipes being drawn from the solid, and being therefore seamless. The plumber has now only to bend, solder, fit, and fix his pipes.

Bending Lead Pipes.—In bending lead pipes various methods are adopted. Pipes of small bore require very little manipulation beyond making the bends as round and open as the situation will allow, the great aim being to prevent the pipe getting flattened, and the bore reduced, at the bend. In larger pipes, say from 1¼ in. to 2 in., greater skill is required.

Spiral steel springs are sometimes used. The pipe is laid on the bench and made quite straight, and a small mandrel is driven through it to remove all dents and marks. The shape of the bend is marked full-size on the bench, and the spring forced inside the pipe (fig. 60) to the place where the bend is wanted; the knee is placed on the pipe, while the end is pulled up little by little till the desired shape is arrived at. The pipe is then gently dressed on either side, each blow being given towards the outside curve of the bend; this helps to loosen the lead around the spring and facilitates its withdrawal. An iron hook is pushed up the pipe and fixed in the ring at the end of the spring, and this is firmly twisted inwards, to reduce the size, and pulled out. Springs should not be used if the pipe is thin, as they weaken the metal very much at the outside of the bend, very often tearing it apart.

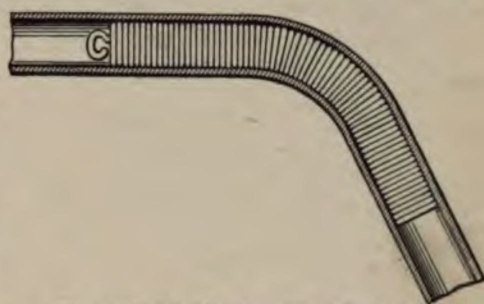


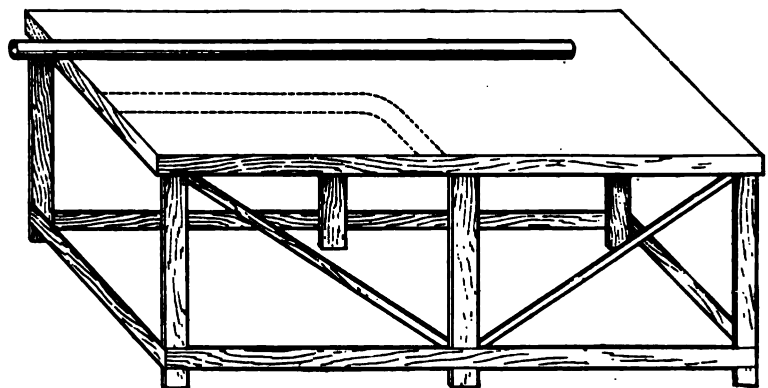
Fig. 60.—Pipe-bending by means of Steel Spring

Another method of bending $1\frac{1}{4}$-in. and $1\frac{1}{2}$-in. pipe is to close one end and fill the length with fine sand, well and closely rammed, stopping up the other end so that no sand can escape. The pipe can then be bent to any radius with little damage to its shape, and can be easily worked backwards on the sand core. The sealed ends are cut off, the sand removed, and the pipe is ready for fixing.

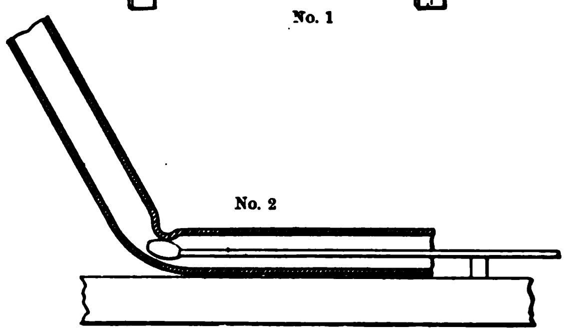
A third way is to slightly flatten the pipe where the bend is required. When a round pipe is bent, the operation causes a flattening of the sides forming the inner and outer curves of the bend, and a corresponding bulging outwards of the two other sides. To counteract the ill effects of this the two latter sides must be flattened before the bending is begun; as the pipe is bent, the flattened sides bulge out to nearly their original shape. The pipe will, however, be contracted a little in the throat of the bend, and to open this a bobbin is placed in the pipe and driven through by a number of short pieces of hardwood, known as followers. The pipe is kept soft by a blow-lamp or gas-jet applied to that portion of the pipe that requires stretching. Another way of driving the bobbin is to use a ball of hardened lead, and drop it down the pipe like a loose hammer, thus moving the bobbin inch by inch till the pipe is of true and full bore throughout.

Bending Larger Pipes.—In bending larger pipes, such as lead soil-pipes, the methods are quite different. As these pipes are always of lighter material than the smaller sizes, the substance of the metal has to be worked away from the throat into the back or o[illegible] e bore of the pipe enables a dummy to be used i[illegible] e skill is necessary, and a few instructions will [illegible] inner. The bend required should first be [illegible] ain chalk lines (fig. 61, No. 1), and [illegible] remove any dents in it.

If the bend is near the end of the pipe, a short mandrel should be fixed in the end to give a greater purchase; then, with a knee placed on the pipe at the point where the bend is required, the end is pulled upwards. In doing this the knee sinks into the pipe and the sides bulge out, a buckle being formed in the throat (No. 2). It is then laid on its side on a piece of thick cloth. With a heavy dresser, made of soft-wood, the lead projecting at the sides is driven towards the back of the bend, care being taken that each blow may be in the right direction and that no dresser marks are made on the surface of the metal. This is repeated on the opposite side,



No. 1



No. 2

Fig. 61.—Bending a Soil-pipe.

the cross-section of the bend assuming a D-shape with the throat dented in. This is now turned upwards, and a dummy is used to work out the surplus lead in the throat as shown. While the mate is working this outwards, the plumber, with a bent bending-dresser, keeps working the metal backwards to the outer radius of the pipe. By these means the pipe is gradually worked to a circular shape and of equal thickness throughout. The operations are repeated until the pipe has been brought to the required position indicated on the setting-out. It is better not to bend the pipe too far at once, as this makes it much more difficult to work the metal evenly in the bend. A "square" bend—that is to say, a quarter-circle bend—should be bent at least four times, and worked out to the full size each time. If too much is attempted at once, the bulged sides are apt to thicken in the working, and the inside of the throat will become uneven in thick-

PASSING THE BOBBIN, WITH WEIGHT ATTACHED, THROUGH A DOUBLE BEND

WORKING OUT THE THROAT OF A BEND WITH THE DUMMY

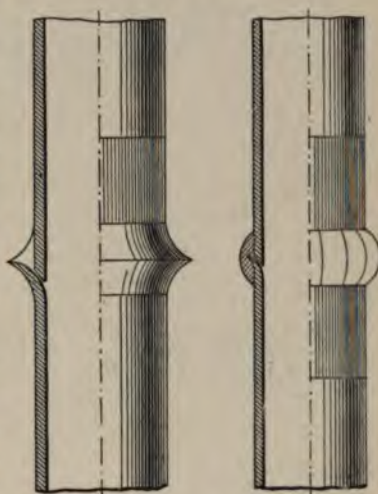
LEAD-PIPE BENDING

ness and be liable to crack. The buckled and cracked bends seen on stacks of soil-pipe are nearly always the result of defective workmanship.

If the bend is near the middle of the pipe, a long-handled dummy is used to work out the throat, as well as to keep the metal from getting into ridges of unequal thickness at the side while being worked backwards. It is best to have the bend worked out to its full size with the dummy. A bobbin is then introduced into it, and driven through with a rounded weight attached to the middle of a strong cord. In its passage through, the pipe is dressed on to it, all dents, buckles, and marks removed, and the bend left quite cylindrical.

Joints in Lead Pipes.—Lead pipes are joined together by means of solder in various ways, the solder used being different for each method.

The cup joint (Fig. 62, No. 1) is the simplest but not the best. The ends of the pipe are rasped square; one end is opened out with a turnpin and shaved clean inside the widened cup, and the other is rasped to a tapered edge and shaved. The tapered end is placed in the cup, the annular space dusted over with resin as a flux, and solder is melted into the joint by means of a blow-lamp or a copper-bit, sufficient heat being applied to tin the shaved pipe thoroughly and sweat the solder into the joint, filling it quite full. Solder for this is called "fine", and is composed of 1 part of tin to 1 of lead by weight.



No. 1 No. 2

Fig. 62.—Copper-bit Joints

Copper-bit joints are sometimes made on lead waste-pipes. In preparing for these, the ends are soiled for about 2 in., one end is opened, and both are rasped to a feather-edge (fig. 62, No. 2), so that when brought together one enters about $\frac{1}{4}$ in. into the other and forms a nearly close union. The ends are shaved to form a joint $\frac{1}{2}$ in. in width, and are rubbed over with pounded resin. The solder is melted on to the joint with the copper-bit, and well tinned, the pipe being gradually turned so that the tool and the melted solder are always at the top. After sufficient solder has been put on to form the joint, it is again dusted with resin, and the joint is floated round; to do this successfully the bit must not be too hot, and should be held lightly on the metal, melting it slowly while the pipe is steadily kept turning round. All inequalities and surplus solder are thus removed, leaving a smooth ribbon of solder encircling the pipe, and making a good reliable joint. Solder for this work must be made up of 1 lb. of lead to $\frac{3}{4}$ lb. of tin, and run out

It is a pity that so many plumbers, especially in London, in the proper use of the copper-bit They are so afraid tinkers that they will rather make a wiped joint even joint would be better.

Wiped Joints (see Plate VII).—The ordinary forms of joint-wiping are underhand, upright, flange, block, and branch joints. For an underhand joint (fig. 63) the ends are thoroughly cleaned from all grease, and are coated for a few inches with good soil or smudge. The ends of the two pipes are opened, one a little more than the other, and the edges carefully and evenly rasped to a feather-edge. They are then shaved quite clean and rubbed over with tallow. When joined they should form a close-fitting union with a clear waterway through (No. 2). The work, if done on the bench, should be laid on a pair of bench-blocks, and securely and firmly fixed with steel points and ties, so that the joint may not move while it is being wiped. The joint should be at least 5 in. clear of the bench, and a piece of stout brown paper placed underneath to catch the spare solder. The solder, which is generally 2 parts by weight of lead to 1 of tin, is melted and heated to a temperature that will brown a piece of dry wood when placed in it. The plumber uses a fairly-large wiping-cloth, which he holds with his left hand underneath the pipe (No. 3), while he pours the solder from a ladle with his right over the joint and the soiled pipe. The metal must be always changing its direction, as a constant stream on one part would melt the lead. The solder runs round the pipe, falling into the cloth held underneath, and is brought on to the top, heated with more metal, and kept moving till the pipe has been sufficiently heated and tinned. All cold metal is then cleared away and the cloth quickly passed round the pipe in one direction, the outside edges being held firmly to the lead, so that a convex ring of solder is formed around the joint. The wiping makes the joint homogeneous and of an even temperature throughout.

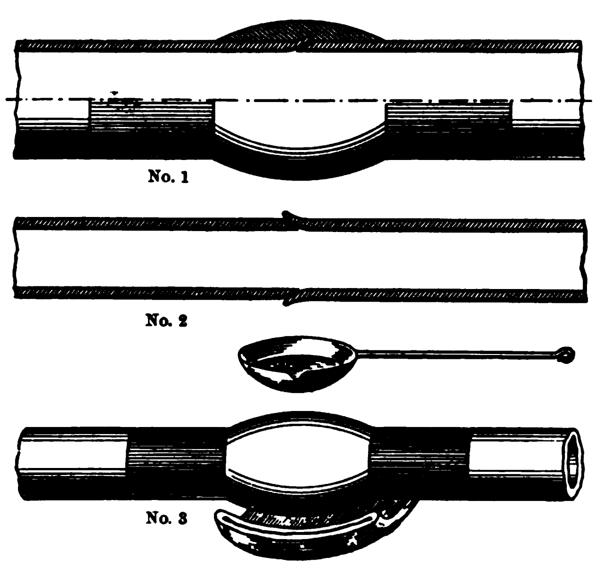


Fig. 63.—Underhand Wiped Joint

The hotter and quicker a joint is wiped, the more reliable it will be. If the metal is wiped when nearly cold there is a chance of cracking, and the surface presents a rough chalky appearance, showing that it has been disturbed while setting and that it will probably prove to be porous. In wiping any underhand joint, the pipe must be heated for a considerable distance beyond the joint itself, the hottest place being at the edge of the cleaning, as there the metal lies thinnest and quickly cools, while the centre, having more metal on it, retains the heat longer. If this is

not seen to, the workman will find that he cannot get clean edges to his work, and has to disfigure it by showing knife-marks where he has had to trim them. The cloth must be of sufficient thickness to form the joint when held against the pipe; some plumbers use a piece of stiff bent cardboard inside the cloth to help them in this. The surface of the cloth must be quite smooth and well soaked with tallow. Unless these details are attended to, the joint is sure to be irregular in shape, and not a credit to the workman.

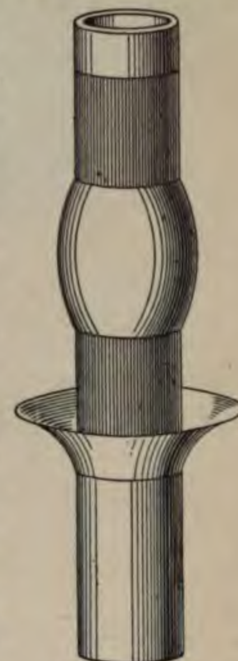


Fig. 64.—Upright Wiped Joint

When a joint is wiped in an upright position it is similarly prepared, but under the joint a lead collar (fig. 64) is fastened round the pipe, forming a cup. This must be well soiled to prevent the solder melting it. The metal is splashed on to the joint from the ladle by means of a splash-stick, and runs down the side of the joint and falls into the cup; this gradually heats the pipe until the surface is tinned all over. The metal is picked up with the splash-stick and placed on the joint, and more metal is put on, until there is sufficient to heat the pipe and form the joint. With a cloth the metal is carefully brought up from the cup and the pipe, and the joint patted roughly into shape. The edges are then cleared of cold metal. With the right hand holding the wiping-cloth so that the first finger presses on the top edge of the joint, and the fourth finger on the bottom edge, the metal is wiped from the back to the front. The hand is then reversed, and the metal is wiped round to the back, the first finger being at the bottom and the fourth at the top. The wiping is continued around the pipe, in one direction, till the joint is perfectly formed. The surplus metal is then wiped downwards off the joint with a small cloth, and, if it has been quickly and skilfully done, a perfectly symmetrical and reliable joint is the result.

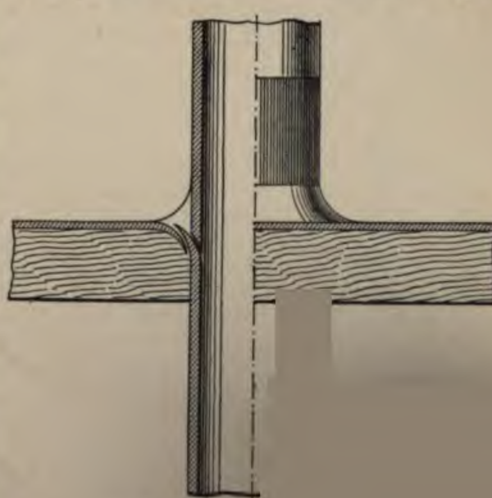
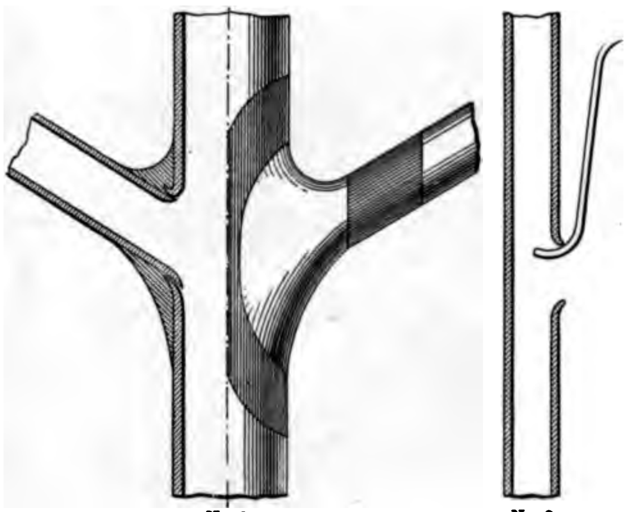


Fig. 65.—Wip

The Block Joint.—Another form of upright joint is that known as a block joint (fig. 65). For pipes fixed inside a building it is not only a safe joint but a good fixing for the pipe. A block of wood, through which a round hole is made, is fixed to the wall, the upper

countersunk and rounded on the edge. The block is covered with a lead flange, which is dressed into the chamfered hole, and the lower lead pipe is passed through the hole and widened out with the turnpin till it nearly fits back on the flange; the pipe is shaved inside and out, as also is the flange where it is dressed into the hole in the block. The upper pipe is prepared as for an ordinary upright joint, and placed in the widened end of the lower pipe; the whole is then rubbed over with "touch". The metal is splashed on to the joint till the prepared surface is tinned, and the solder sweated into the space between the pipes and on to the lead flange; the joint is then wiped round with a small thick cloth, forming a collar which holds the pipe for a distance of 2½ in. It is essential for the success of these joints that they be tinned and sweated thoroughly.



No. 1 No. 2

Fig. 66.—Wiped Branch Joint

Branch joints (fig. 66) are made where one pipe has to be inserted into the side of another. A small hole is made in the main pipe with a tapered gimlet, and is then widened out to the size required with a small hammer and bending-bolt (No. 2), the lead being worked outwards, forming a short socket. The branch is tapered and fitted into this socket accurately, so as not to obstruct the water-way of the main pipe. A sheet-metal marked gauge and compass are used to scribe the dimensions of the joint. After fitting, the pipes are soiled and prepared as for an ordinary underhand joint. The pipes are then firmly fixed, and a shelf fixed below the joint to catch the solder, which is splashed on from the ladle and picked up on the joint, until the latter is all tinned and heated. It is wiped off in a similar way to an upright joint, but with a smaller cloth.

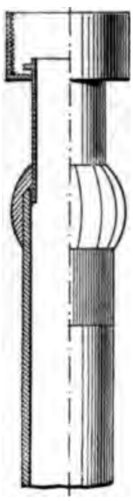


Fig. 67.—Joint between Lead and Brass.

The Plumbing-iron.—In making any of these joints it is not always possible to finish them without auxiliary heat, as the solder cools so rapidly. A plumbing-iron heated red-hot is sometimes necessary to keep up the heat of the joint. It is false pride to refuse to use this tool. We should all try to be expert, but it is better to be sure, and many a plumber finds himself in a fix with his metal that only a good hot iron can successfully take him out of.

Brass-to-Lead Joints.—In jointing brass fittings to lead the brass must first be filed clean where the solder is to be applied, and tinned with fine solder, resin being used as the flux, and the copper-bit as the tool (fig. 67). To fix the brass into the pipe a groove is filed all round the fitting, close to the end where it fits into the pipe; the edge of the latter is hammered into the groove to prevent any movement while the joint is being wiped. When pouring or splashing the metal on a lead-and-brass joint, care must be taken to bring both metals to the same heat, and to wipe the metal from the brass first, and also to wipe the joint quickly, as the solder cools more rapidly and unequally than on a lead-to-lead joint.

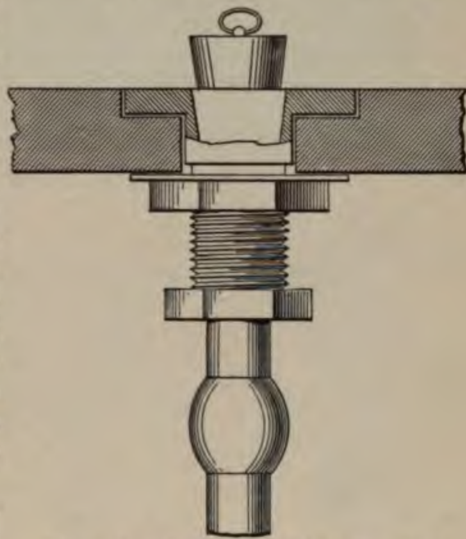


Fig. 68.—Brass Connection for Joint between Lead and Pottery

Lead-to-Earthenware Joints.—Joints between lead and earthenware may be made with solder if the earthenware is specially prepared so that the solder can be tinned on to it. For example, some water-closets are sent out by the makers with short pieces of lead pipe attached to the outlets, so that the plumber can make a wiped joint between them and the lead soil-pipe. The best way of joining lead traps or pipes to pottery sinks and lavatories is by brass connections (fig. 68). These have a flange on the top, which presses on the inside of the fitting, and a fly-nut is screwed up against the outside, the joint being made water-tight with a rubber ring or a grummet of twisted hemp and red-lead. A cap-and-lining or half-union is screwed to the fitting after being wiped on to the lead trap.

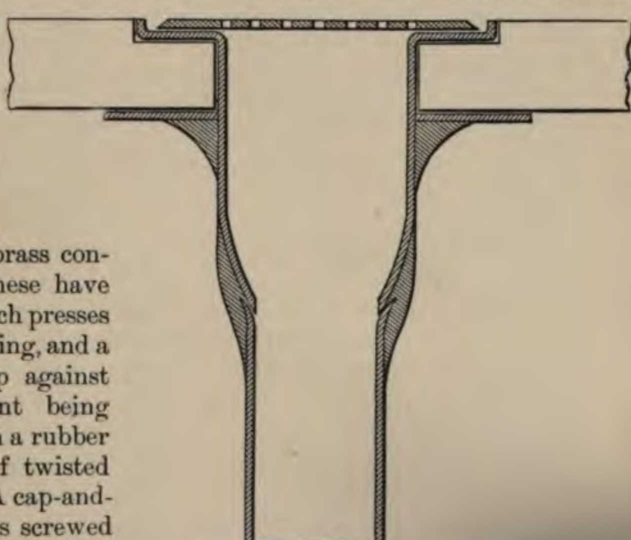
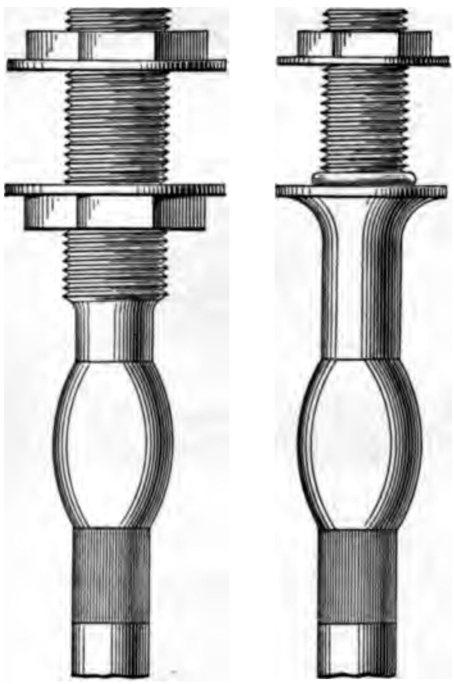


Fig. 69.—Lead Cone Joint between Lead

Flange Joint.—Another method which is often adopted, w union connection is thought too expensive, is to have a co pipe (fig. 69) fitted through the outlet of the sink, and t

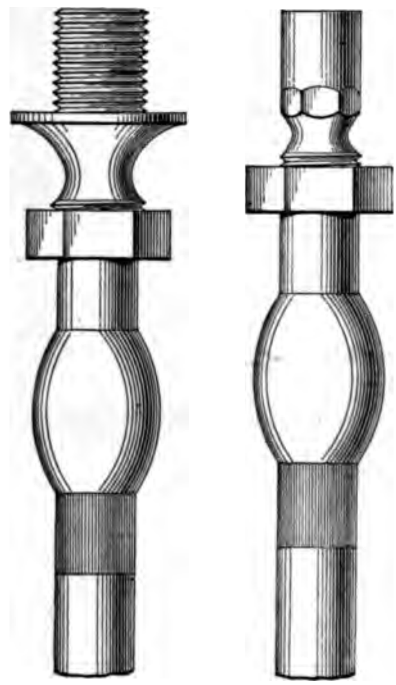
of the waste-pipe, to which it is soldered. A lead flange is fitted and wiped to the cone and pressed against the under side of the sink-bottom, the top of the cone projecting into the sink. The joint between the lead and the earthenware is made with stiff red-lead. The projecting portion of the cone is tafted over into the countersunk space in the outlet, forming a flange, to which the brass grating is soldered. This stiffens the flange and completes a fairly-good joint.

Lead Joints with Slate or Galvanized Iron.—For making connections between lead pipes and slate or galvanized-iron cisterns, boiler-screws are



No. 1 No. 2

Fig. 70.—Boiler-screw Unions



No. 1 No. 2

Fig. 71.—Lead-to-Iron Unions

generally used. These are cast-brass tubes, plain at one end for soldering, and screwed on the outside for half their length. Two broad flange-nuts are run on to this screw (fig. 70, No. 1). The plain end is soldered to the lead pipe; one nut is removed and a rubber ring or grummet slipped on to the screw. The end of the latter is then passed through the hole drilled in the cistern, another washer put on, and the nuts screwed up. This squeezes the washers and makes a water-tight joint. Another form of boiler-screw has a flange cast on it and only one nut (fig. 70, No. 2), but the first-named is the most convenient, as the fitting can by it be tightened up both inside and out.

Lead-to-Iron Unions.—To connect a lead pipe to a wrought-iron tube requires a lead-to-iron union (fig. 71). One end is tinned and soldered to the lead, and the other is screwed into the socket of the iron barrel (No. 1), or

forms a socket for the iron pipe (No. 2). It is not a good plan to solder iron and lead pipes together, though it is often done in very cheap work. Solder does not readily tin to iron, and when it is tinned it is not reliable or durable.

Expansion-joints in Pipes.—In long lead waste-pipes, through which hot water passes, it is not advisable to use soldered joints, as a long rigid pipe will buckle and crack through the expansion and contraction of the metal under the varying temperatures. Such pipes should be in short lengths, fixed at one end only, and jointed so that while tight they are not "bound". In vertical wastes (fig. 72, No. 1) a 12-ft. length may be cut in two. With

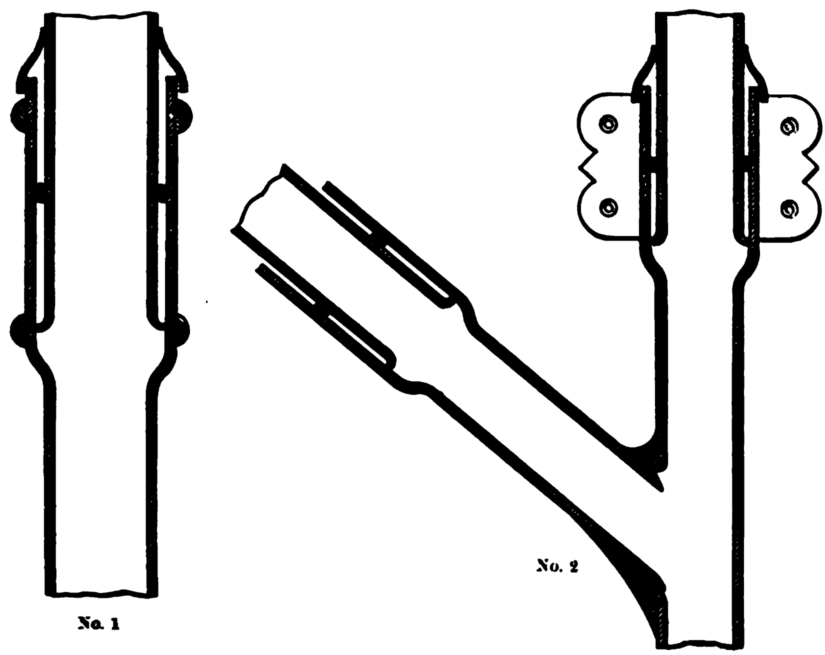


Fig. 72.—Expansion-joints in Lead Pipes.

a reducing mandrel the upper end of one pipe is expanded for 6 in. to form a socket or faucet, around which two astragal beads may be fitted and soldered. Two cast-lead ears are soldered on each socket, and are fixed to the wall with galvanized pipe-nails. Another length is prepared, the spigot end having a rubber ring stretched over it, which, when the end is inserted into the socket of the lower length, fills up the annular space between the two pipes. The upper pipe must not be allowed to go to the bottom of the socket, but should stop a good inch from it. When hot water passes through it, the pipe is free to expand downwards, rolling the rubber ring with it: as it cools it contracts back to its old position. A loose lead collar is generally slipped over the upper pipe to prevent water or rubbish getting into the joint. No tacks or attachments of any sort should be fixed to the pipe between the joints.

When a branch is attached to a long vertical waste-pipe (fig. 72, No. 2)

a short stump with an expansion socket must be soldered in, and the horizontal branch fixed in short lengths with similar joints. Pipes passing through a wall should have joints close to the inside and out, or should pass freely through pipes of larger diameter built in the wall.

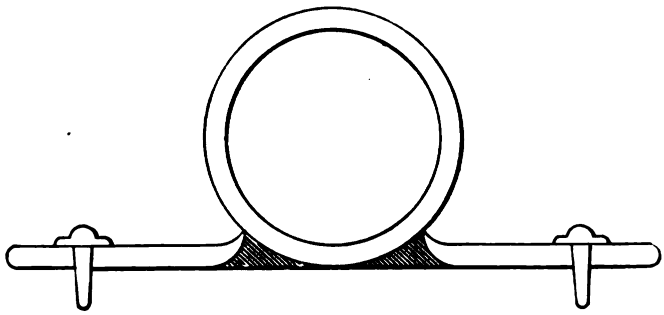


Fig. 73.—Cast-lead Tacks for Soil-pipe

Soil-pipes are generally fixed in 10-ft. lengths, with three pairs of stout cast-lead tacks (fig. 73) soldered to them in such a way that they may lie flat on the wall, and have a strong hold on the back of the pipe, and that each may support an equal share of the weight. Each tack has two holes, through which nails are driven into hardwood plugs fixed in the wall. In fixing these pipes great care must be taken that the tacks are properly tinned and soldered to the pipe, that they fit the wall, and that each nail is useful. As they are nearly always fixed externally, the sun has a good deal of effect on them, and loose fixing soon yields to its influence, with the result of a zigzag appearance and an occasional crack or a buckle at a faulty bend.

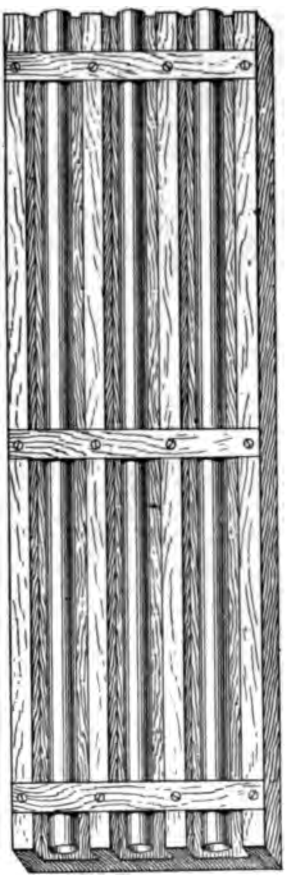


Fig. 74. –Pipes in Wood Casing

Slop-sinks discharge in all cases into soil-pipes, and it should be imperative that no hot-water tap be fixed over them or any hot water poured down. Nearly all the defects in lead soil-pipes are caused by hot water and slipshod fixing.

Arranging and Fixing Pipes.—Ordinary lead service-pipes are fixed by means of pipe-hooks, wall-hooks, tacks, clips, and carrying-battens. All pipes should be laid with falls to draw-offs, so that when the water is turned off they may be easily emptied. Where they are against external walls, or on any brick wall, a board should be fixed behind them, upon which they can be dressed quite straight and conveniently fixed. Pipes should, as far as convenient, be grouped together and easy of access. In some parts of the country all vertical main pipes for service purposes are fixed on boards in a recess, with fillets of wood between the pipes (fig. 74), so that these cannot buckle to

either side. To prevent outward buckling the front of the recess has a hinged door that fits and latches close to the fillets for the full length of the vertical portion. The pipes are supported on a lead flange, through which each pipe passes and to which it is soldered, the fillet being cut to support the flange. The horizontal pipes, if on a wall, lie each on its own fillet or shelf, perfectly free and easily accessible; if on the flat, they lie side by side, but not touching each other. Where hot and cold pipes are in the same casing, it is important that they should not touch, and the method of fixing by fillets entirely obviates this.

If the fixing is to be with *pipe-hooks* or *wall-hooks*, it is best to take a piece of doubled lead and fold it round the pipe, so that the sharp edge of the hook may not cut the lead; or a piece of wood may be placed between the hook and the pipe. Any way of fixing with hooks looks unsightly and is not satisfactory.

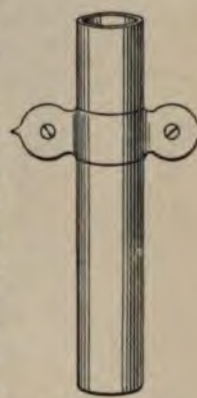


Fig. 75.—Pipe-clip

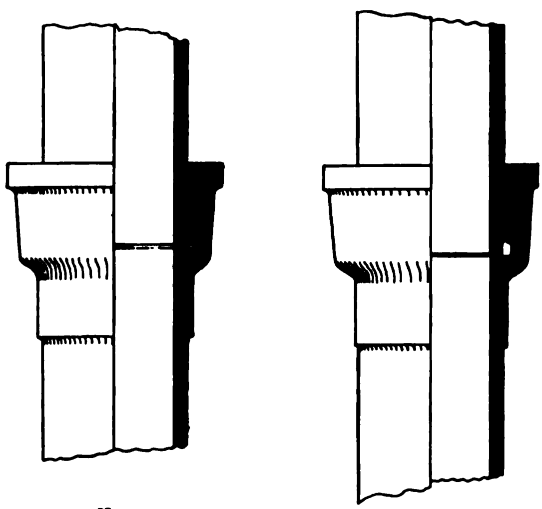
Iron or brass clips (fig. 75) are sometimes used. These are fitted round the pipe and screwed to the back-board or wall, and are better than hooks. Sometimes the clips are made of thick sheet-lead, but these are apt to get loose. Small lead tacks, soldered to the side of the pipe and screwed to the back-board, make good fixing for vertical pipes. All these fixings are, however, defective for horizontal work, as the lead pipe sags between the hook, clip, or tack, forming a series of traps, which, in the case of a low service from a cistern, become air-bound every time the cistern is emptied. The only satisfactory way of fixing horizontal lead pipes is by laying them on wooden fillets and fixing them to the wall with tacks or half-clips, so that they are supported throughout their length.

Anti-siphonage pipes are fixed to the outgoes of water-closets as near the trap as possible. The connection to the branch should be made so that the pipe points in the same direction as the water goes; this prevents the anti-siphonage pipe getting choked. If a connection has to be made to the earthenware nozzle of the apparatus, a brass ferrule is soldered to the lead pipe and a cement joint made between the brass and the earthenware. The anti-siphonage pipe is fixed in the same way as a soil-pipe, with three pairs of cast-lead tacks to a length, and with soldered and wiped joints, and carried up to a distance of at least 6 ft. above the highest water-closet, receiving a branch from every water-closet as it ascends, and turning at the top into the vent-pipe from the water-closets, or carried up separately to the same height.

CHAPTER IV

IRON- AND COPPER-PIPE WORK

Cast-iron Pipes.—Cast-iron pipes are now very often used for drains, soil-pipes, and waste-pipes, and the plumber ought therefore to be familiar with the material and understand the best methods of fitting, fixing, and jointing it. In towns where the vibration of the earth is considerable, it can be recommended for use in drainage in place of earthenware pipes. The pipes are manufactured in various lengths, up to 9 ft. They are of great strength and protected from corrosion by being dipped while hot in a solution of bitumen (invented by Dr. Angus Smith), which leaves them with a practically impervious surface in and out. The different fittings required, such as intercepting-chambers, access-eyes, gullies, bends and junctions, and diminishing-pieces, can be procured from the makers ready for fixing. It is now invariably the practice for the plumber to lay cast-iron drains. The intercepting trap and chamber are placed as near the boundary of the premises as possible, and the trap is connected to the branch from the sewer, the branch being, in London, invariably of stoneware. The chamber is in a solid casting with sockets cast on at the required angles. The drain is laid in as long lengths as possible, and with a declivity of about 3 in. in 10 ft. throughout its length. Chambers in cast-iron are fixed at the points where the drain changes direction or where branches join it. All chambers should be laid with slightly more fall than the drain, so that they will thoroughly drain themselves out, and will not retard the flow of the sewage.



No. 1 No. 2.

Fig. 76.—Joints in Cast-iron Pipes

Cutting Cast-iron Pipes.—In cutting lengths of pipe a hammer and chisel should not be used, as the concussion of the hammer is likely to crack and damage the anti-corrosion coating of the pipes. One of Jones's multiple-wheel cutters (fig. 36, No. 3) will cut the pipe without risk of cracking it or damaging the enamel.

Joining Cast-iron Pipes.—To joint the pipes they must first be levelled to their exact position, the spigot end being sent well home into the socket, and each length should be supported on concrete or brick piers about 4 ft. apart. Flax, gasket, or tarred yarn is folded round the pipe (fig. 76, No. 1)

and driven by means of a yarning tool into the joint, the ends of the yarn being kept out till two rings of the material have been driven home to the bottom; then the whole of the packing is tightly driven in, half-filling the annular cavity in the joint. A fillet of milled clay is then folded round the opening in the socket, and a cup formed where it joins at the top. Into this molten lead is poured, filling completely the joint in front of the yarn. The clay is then removed, and the plumber proceeds to caulk or stave the lead into the joint. A chisel is first used to clear the metal from the side of the pipe; this prepares the joint for the first square-faced caulking-tool, which half-fills the joint. After driving this all round into the lead, the plumber uses the second tool, which almost fills the joint and leaves a smooth surface on the caulked lead. With the chisel the surplus lead is removed, and if the yarn has been closely packed the metal has not been driven past the edge of the socket, and a thoroughly successful joint has been made, that will resist a great pressure of water. If the connection is in an awkward place, specially-set caulking-tools are necessary, and in most shops a set of twisted tools is kept for this purpose. All joints on iron drain-pipes are made in this way, whether into chambers, gullies, bends, or branches.

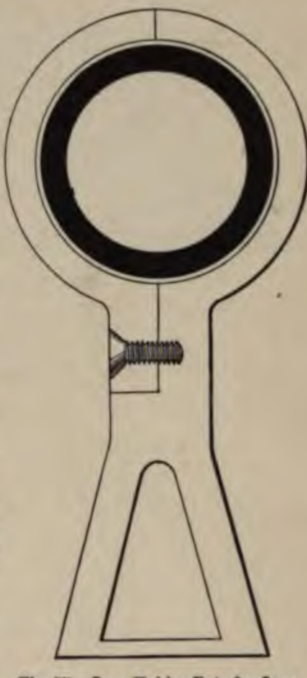


Fig. 77.—Iron Holder Bats for Iron Soil-pipes

Cast-iron water-mains, where laid underground, are jointed in the same way, but it is not advisable to use *tarred* gasket for the packing. In pipes under pressure the yarn absorbs a certain quantity of the water, swells, and almost makes the joint tight without the lead.

Cast-iron pipes are also extensively used for conveying gas under streets and roadways. The metal is not coated in the same way as for water-mains or drain-pipes, and the jointing is different. The inside of the socket is turned out cone-shaped for half the depth (fig. 76, No. 2), and a hollow groove is cast close to the outlet of the socket. The spigot end is turned to fit into the turned-out socket, and both are coated with a prepared paint, and are driven into each other with a wood mallet of great weight. The space in the mouth of the joint is run full of molten lead, and caulked in a similar way to the water-pipe.

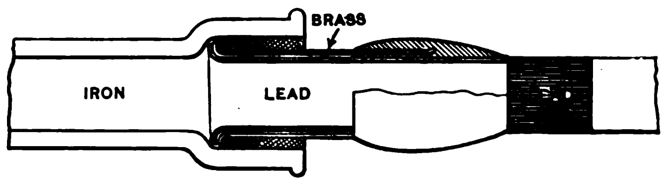
Cast-iron soil- and waste-pipes are either coated with the impervious enamel or are galvanized, that is, coated in and out with molten zinc after being immersed in an acid bath.

Soil-pipes should be fixed 2 in. off the wall by means of holder bats (fig. 77). These are fixed in the wall with [illegible] d are in two halves, which together encircle the pipe-socket [illegible] hinged and keyed together, support the weight of [illegible] ent room to make the joints. Sometimes the [illegible] ide of

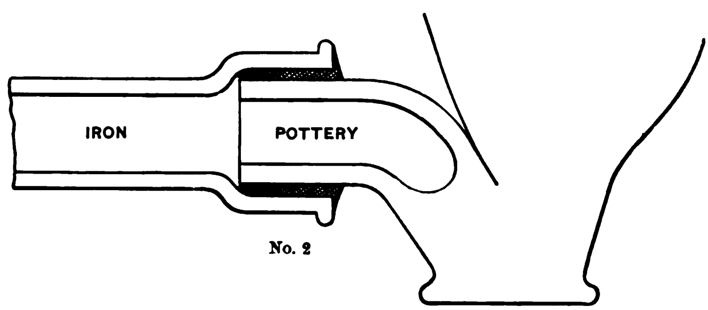
the socket, through which they are fixed with wrought-iron pipe-nails driven into wooden plugs in the wall. The joints are made either with gasket and molten lead, as in underground pipes, or with gasket and red-lead packed in alternate layers, well staved in and neatly wiped off.

Cast-iron vent-, anti-siphonage, and waste-pipes are fixed and jointed in exactly the same way as soil-pipes..

The earthenware trap of a water-closet may be fitted into a cast-iron bend having a specially wide socket (fig. 78, No. 2), and jointed with a ring of gasket filled up with Portland cement. If the trap of the water-closet is of lead, a brass ferrule is soldered to the outgo (No. 1), and caulked with



No. 1



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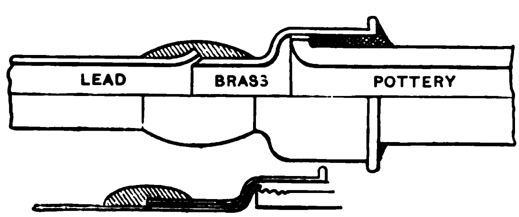

No. 3

Fig. 78.—Joints between Water-closets and Iron Soil-pipes

gasket and lead to the iron socket. In many cases the iron soil-pipe is not carried inside the building, a lead branch and bend being used to connect the water-closet to it. A sleeve-piece or ferrule is soldered to the lower end, as in No. 1, and a socket to the other (No. 3). The former is caulked to the iron pipe, and the upper receives the water-closet trap, which is jointed with gasket and cement as before described.

Cast-iron pipes for low-pressure hot-water apparatus are extensively used for green-house and other work where a large heating surface is required. There are many methods of jointing these. Some fitters use

yarn and Portland cement, and say that the joint stands well if the yarn is well driven home and the cement is not "killed", or the pipe moved till it has thoroughly set. Gasket and red-lead, caulked in hard layers and well staved-in, make a good joint.

Rust joints are often used for socketed hot-water pipes, and are, if properly made, thoroughly satisfactory. The rust cement is composed of cast-iron borings, sal ammoniac, and flour of sulphur in varying proportions, according as the cement is required to set quickly or slowly. A quick-setting cement may be made of 1 part of sal ammoniac, 2 parts of flour of sulphur, and 80 of iron borings by weight; and a slow-setting cement of 2 parts of sal ammoniac, 1 of flour of sulphur, and 200 of iron borings. To free the iron borings from oil and grease they must be heated red-hot, and made perfectly clean. They must then be pounded or crushed as small as possible, and mixed dry with the other ingredients. After being thoroughly mixed, the ingredients must be slightly damped and again mixed. Rusting soon begins, the cement getting quite hot in the process. The inside of the socket and the outside of the spigot of the pipe must be entirely freed from oil, grease, and paint. The joint is filled with the cement, which quickly fastens on to the metal in the socket, rusting and expanding till the borings become a solid mass, and a joint made that will stand any pressure.

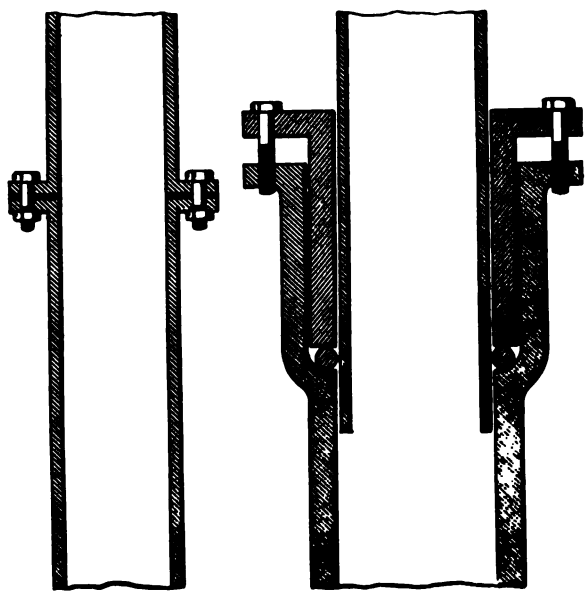
No. 1 No. 2

Fig. 79.—Joints in Cast-iron Heating-pipes

Flange-jointing.—Another way of jointing is to have the pipes cast with flanges, and to use a rubber ring between the flanges, which are drawn together by bolts and nuts (fig. 79, No. 1). By this method a length of pipe or a fitting can be removed without cutting or disturbing the other joints. Socketed pipes are sometimes made with ears cast on the end of the socket; a loose socket (also with ears) is slipped over the pipe (fig. 79, No. 2), and when the pipes are put together a rubber ring is forced into the open joint, the loose socket placed against it and two bolts through the ears draw them together and press against the rubber ring forming a good sound joint, which has the additional merit of being an expanding connection.

Joints on **rain-water pipes** are made with red-lead putty. In fixing them it is best that each pipe should be suspended by its own ears, and the spigot of one length be at least ½ in. from the bottom of the socket. The joint must be filled throughout with the cement, so that water running down the outside of the pipe may not find its way inside. If rain lodges in the socket, frost will cause the water to expand, and may burst the socket. It is better to have rain-water pipes with open joints, so that dust and rain will run through the socket into the pipe, than to have them half-jointed. If rain-water pipes are large enough to take all the water that may be discharged from the roof, it is an advantage to have them with open joints, as they are less likely to get stopped, and any damage caused by stopping is limited to one length.

Wrought-iron pipes are now in use for numerous purposes in house-plumbing, particularly for water-services and gas-pipes. Gas-barrel is butt-welded and made of thinner metal than those for water and steam, and cannot stand the same amount of pressure, or be so easily bent. Water- and steam-barrel are lap-welded; that is to say, the material of which the pipe is made up is overlapped at the seam, and the weld is therefore stronger and not so liable to split when the pipe is being bent or screwed.

Wheel-cutter.—For cutting barrel a wheel-cutter (fig. 36) is used. The pipe is fixed in a vice, and the cutters rotated round it, the wheel being pressed into the pipe by means of a screw until the metal is cut completely through. Sometimes a file is used to cut the metal half-way through, and a quick jerk in the vice snaps the pipe where it has been filed. The ends of the pipe are screwed to a standard thread, and sockets with an internal screw of the same standard pitch are used for joining the lengths of pipe. For gas-work the threads of the screw are coated with red-lead paint, and are screwed together with pipe-tongs, the red-lead being sufficient to stop effectively any leakage of gas. For water-supply the ends of the pipe and the socket are coated with gold-size, and a few threads of dressed hemp wound round the screw on the end of the pipe. This is screwed into the socket, and, with the gold-size, fills up the joint and makes it water-tight and capable of standing considerable pressure. For hot-water and steam a paint made up of red-lead and gold-size, with a hemp packing, makes a very good and reliable joint.

Bending.—In fixing hot-water and steam barrel it is often necessary to make sets and bends to fit into the various places required. It is best to take a piece of stout wire and make a template of the exact bend required, and to set this out on the floor or bench. The barrel is heated to a dull red, and bent over a wood or iron block. The bending is regulated and the pipe cooled where required with a little water; the least drain of water poured on the hot iron stops it from bending at that point, and enables the workman to make a neat, sound, and true bend to the template set out.

Wrought-iron pipes can also be bent cold by means of a bending machine, such as Kennedy's (fig. 80), in which the pipe is bent around a ring of the proper radius. The size shown is suitable for copper, brass, and iron tubes up to 2 inches in diameter.

Where made bends are fixed, it is usual to fit connectors or running sockets to them (fig. 81). The barrel is screwed with an equal thread for a distance of 3 in.; on this is run a back-nut, or, as some term it, a jam-nut, the outer face of which is turned out hollow. A socket is also threaded on to the screwed pipe. The pipe is butted against the screw of the next length, the joint painted and packed, the socket run up tight on the short screw, and a grummet of twisted hemp soaked in red-lead is put behind the socket on the screwed pipe; the back-nut is screwed up hard against the socket, squeezing the grummet between. This is a joint that can easily be undone when any repairs or alterations are required. Plumbers, when fitting up iron pipes for any purpose, should never fail to fix connectors at many points, as means of access to the pipe systems.

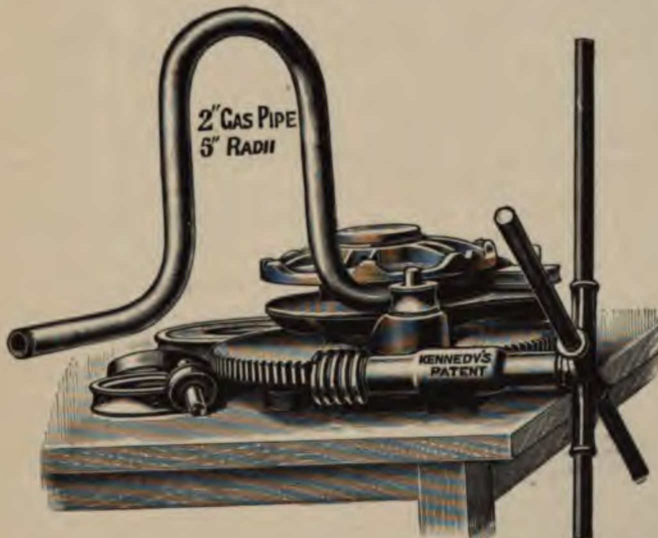

Fig. 80.—Kennedy's Patent Pipe-bending Machine


Fig. 81.—Connector for Wrought-iron Pipe

Expansion and Contraction.—In fixing long lengths of hot-water pipes, allowance must be made for the expansion and contraction of the pipe during the varying heat. This can be done by making an S or U bend one length, which will receive the thrust of the expanding pipe, a as it cools.

Fixing Wrought-iron Pipes.—Wrought-iron pipes are some with pipe- and wall-hooks, the pipe lying hard against the best to use proper pipe-hooks or suspenders; these are built and have a ring in two halves (fig. 77), of the same size which stands an inch clear of the wall. The pipe is laid in th of the clip, and the other half is added and screwed up ti means the pipe is kept off the wall, and is easily accessible

Jointing to Cisterns.—Where iron pipes are connected to cisterns (fig. 82), a long screw is made on the end of the pipe, and a back-nut is screwed up to the end of the thread, on the face of which a galvanized washer is put. To this is added a hemp grummet soaked in red-lead paint. The end of the pipe is passed through the hole drilled in the cistern, another washer with grummet is placed in position, and the other nut is screwed on, pulling the washer and back-nut against the outside of the cistern, and forming a water-tight joint.

Jointing to Wrought-iron Boiler.—In making a connection to a wrought-iron boiler, it is necessary to drill the metal. This is done on the job by means of a lever-and-ratchet brace, the hole being drilled perfectly true. If the hole required is above an inch in diameter, it is best to drill a small hole first, and then to use a spindle drill; this ensures the hole being drilled cylindrically. The hole is then tapped with a tapered thread to fit the screwed pipe. In the case of the flow-pipe in a circulation, a back-nut should be used. The pipe is screwed into the boiler till it is flush with the inside surface; it must not project into the interior in the slightest. A grummet of hemp is fastened round the pipe, and the back-nut screwed hard down, thus completing the joint. The return pipe should project inside the boiler sufficiently far to allow a short piece of barrel being screwed on; this conducts the returning cool water to the bottom of the boiler, and accelerates the movement of the water when heating. It must be understood that all circulating hot-water pipes, to work efficiently, must be fixed with a distinct fall from the cylinder to the boiler, and have no traps, and, if possible, no acute elbows. Avoid long dead branches, and plan the work so that the main circulation shall pass near the draw-off taps or have subsidiary return branches from each tap.

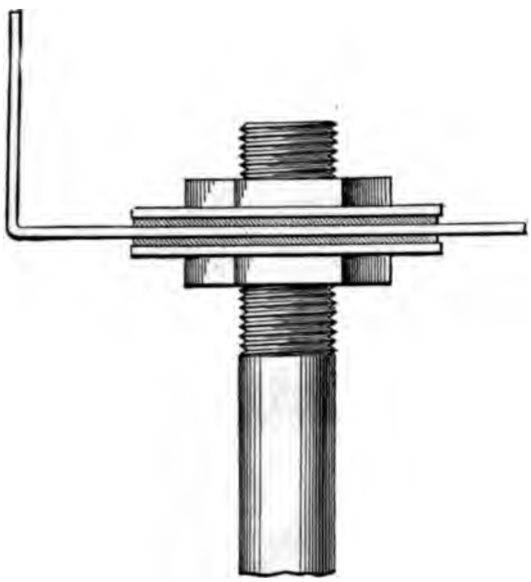

Fig. 82.—Joint between Wrought-iron Pipe and Cistern

Inspection-covers.—Access inspection-holes should be provided in all boilers, especially when hard water is used. The incrustation of fur from the water has to be periodically removed, or else the boiler quickly burns out. The covers to the manholes may be secured with a rubber-ring washer fixed on the lid and squeezed up with a strong screw and an overbridge, or, instead of the rubber, a grummet of plaited hemp in red-lead cement may be used. To be effectual and reliable no oil or paint should be worked into the cement, only plain white- and red-lead,

thoroughly mixed to a stiff paste, and having chopped hemp added to it, and well kneaded in.

Testing Services.—It is always necessary to test iron barrel after fixing, as too often split sockets, cracked bends, and flaws in the fittings are found. In ordinary methods charging the pipes with water at the normal pressure is held to be sufficient, but every plumber's experience shows that defects in iron pipe take some time to develop, and that greater security is assured if a test is applied, for some time at least, double the normal pressure. This is done by means of a small hydraulic pump with an indicating pressure-gauge that will blow open when the required pressure has been given. The expansion-pipe must, of course, be plugged off, and also the inlet from the store-cistern. The pipes should then be carefully examined, and all defects made good. In applying the test to gas-services an air-pump is used with an indicating gauge to tell if any leaks exist.

Copper Pipes.—In many parts of the country, where the water is very soft, iron pipe cannot be used for hot-water services owing to the corrosive

Fig. 83.—Spencer's Brass- and Copper-pipe Bending Tool.

action of the water. It is there customary to use copper for the boiler, cylinder, and circulation-pipes, and this is work that is carried out by the plumber. The pipes used are of solid-drawn material, and are screwed similarly to iron barrel, but brass or gun-metal unions are used for connecting them together. The inside of the union is tapped to the standard gauge, the screw tinned inside and out, and, after being screwed up tight, is sweated through with a copper-bit and fine solder. Sometimes a joint is wiped over the screwed connection, but this is really unnecessary. The halves of the unions are sometimes brazed on to the copper tube. The using of unions enables the workman to take out a length at any point when required, without having to cut away to any extent. The unions to the boiler are either brazed on or are fixed with brass flanges and bolts.

Copper and brass tubes can be bent in various ways. Sometimes the tube is filled with fine sand and the ends are plugged; ... en heated and can be bent to the shape required withou
sand inside the tube preventing the buckling of
Spencer's patent pipe-bending tool (fig. 83), c

2 inches in diameter (outside) can be bent cold without being loaded with sand, provided that the radius of the bend does not exceed four times the diameter of the tube.

CHAPTER V

MISCELLANEOUS WORK

If there is one workman more than another who has to be skilful, intelligent, and painstaking, it is the jobbing plumber, and the number of really good men is limited. Other workmen may make a rough bungling job without injury to anyone beyond offending the æsthetic taste of the customer, but the work under the plumber's charge—the pipes, and all the sanitary fittings—is, when out of order or improperly repaired, a source of danger to health and even to life. He must be intimately familiar with the principles and practice of sanitary plumbing, have a wide acquaintance with the numerous forms of taps, valves, water-closets, flushing-cisterns, &c., in ordinary use, know where to localize and how to remedy defects, and be able to adjust and regulate the various fittings so that they will work for a reasonable length of time without causing trouble.

Repairing a Burst Water-pipe.—To repair a burst water-pipe looks a simple thing, but unless it is done properly the leak will certainly break out again. The ordinary way is to knock the opening up and put a patch of fine solder on it with the copper-bit. This may temporarily stop the leak, but the writer cannot advise a plumber to be content with it. The commonest cause of burst pipes is frost. If a pipe full of water is exposed, the water freezes unequally, and in the process expands. As it cannot find room for its increased bulk in the bore of the pipe, it forces its way through the side, stretching and tearing the metal. It not only bursts the pipe at the point where the ice projects, but also weakens it along the greater part of the distance where the ice has formed. The pipe should be cut out and a new piece put in, the junctions into the service to have wiped-solder joints. If the pipe is frozen near a junction or branch joint, the part of the main pipe is generally bulged (if not burst out) opposite the branch joint; this is done by the thrust of the ice from the branch. This should never be patched up, but cut out, and a new piece substituted.

In some cases the plumber finds lead pipe cracked, a series of cracks appearing when the pipe is moved. On no account should he attempt to mend them, as for every one patched up he will find new ones break out. The cause of these cracks is that the pipe is not made of good lead, or that it has been improperly drawn in the manufacture. The only remedy is to cut out the pipe and substitute a new one of good material.

In searching for leakages in underground pipes it is necessary to open up the ground, and this must be carefully done, so that no damage is done to the pipes. A leakage can always be localized by putting a steel chisel on the pipe where it is exposed, and listening for the hissing noise caused by the escaping water, and following this till the fracture is found. When

it is found, do not attempt to mend it, but cut it right out. If the condition of the pipe shows that the soil or gravel is eating away the lead, cover the new pipe with pine saw-dust; this will act for some time as a preservative.

If you are called in to enquire about wet—or, as many people say, "porous"—pipes in kitchens and rooms where the temperature is high, do not think that they are leaking when you see the water dropping from them, but recognize that the whole trouble is caused by the condensation of the water-vapour, present in the hot air of the room, on the surface of the pipe through which water at a lower temperature is running. The remedy is either to move the pipe from the room or to wrap it with felt or any non-conducting substance, and to cover this with a wooden casing.

If a pipe has been fractured in the street, where it passes over a sewer-trench or where the ground is likely to subside, allow sufficient piping to sink with the ground, a loop being made with the extra length, otherwise the subsiding earth will drag down the pipe and again break it.

Lead flats, where they are in large pieces and are exposed to the hot sun, will sometimes buckle up and crack across, admitting the rain, to the detriment of the ceilings below. In repairing these it is the best plan to open up the crack and to cut a groove in the wood-work below, into which the lead is closely dressed but not nailed. The grooved lead is then shaved clean and a patch wiped-in, flush with the flat. This prevents any obstruction to the water in running off the roof. The same method applies with even greater force to lead gutters.

Gutters are often found to leak at the drips or junctions. The overcloak lead should be carefully raised and the lower lead examined; if leaking, it must be patched and the upstand dressed up carefully. If there is a capillary groove, it should be cleared out and the lead set into it. The overcloak should then be dressed down, and any cracks found in it repaired carefully. Avoid promiscuous patching at the drips, such as soldering the two gutters together, as the cure is often worse than the original trouble, the lead inevitably cracking where it is bound, and often necessitating the relaying of a portion of the gutter. In the case of cracks in ridges and hips, the lead must be cut right across and a new piece put on the ridge to cover the crack, and in a sloping hip slipped under the upper length and nailed there, and overlapping the top of the bottom length. Soldering in such cases is nearly always useless, as new cracks will appear near if not at the soldering.

Clearing a Stopped Pipe.—In clearing a stopped rain-water or waste-pipe the treatment varies according to the conditions. If the pipe is stopped with ice, it is of no use to put hot water in the gutter or on the top of the pipe. It should be poured on the outside of the bottom length; the heat ascends and melts the ice up to the top. If it is a chokage from foreign matter, a cane run down the pipe will sometimes dislodge the obstr which can then be washed down to the gully and removed. it may be necessary to take out a length or a bend at the obstruction; in replacing these it is well to pro

for future use at the bend. In fact all bends ought to be provided with them when first fixed, but unfortunately this is seldom done.

A liberal supply of hot water passed through a vertical waste-pipe will generally dislodge all congealed soap in the pipe. On being called to a stopped sink, first take out the inspection-screw in the trap and remove any sediment collected there. If the stoppage is beyond the trap, it is best to use a force-pump or a forcing-cup, after securely stopping the end of the puff-pipe from the trap. A fruitful source of smell in sinks, lavatory-basins, and baths is the concealed overflow-pipes, which get choked up with soap, hair, and bits of sponge. They must in every case be cleaned out and washed with hot water periodically.

Repairing Taps.—In repairing taps at sinks, the washers used should be of the best material, the seatings cleaned or faced up, and leather used for cold water, and vulcanite or woodite for hot. The stuffing glands round the spindle should be eased and repacked, so that the screw may work easily in pressing down the washers on the seatings. In repairing ball-valves, the fittings and washers should be well fitted and lubricated, so that the levers and the ball may work freely when floated by the rising water in the cistern. Sometimes, when two or more ball-valves are located near each other, they "chatter" when nearly closed. Some plumbers put on ball-valves of different patterns, and say that this prevents the nuisance; but the writer has never found it so, and cannot see how it can do it. The nuisance arises in most cases from the sudden checking of the momentum of the moving water in the pipe by closing a valve quickly, and the concussion thus produced depresses the floating ball in the water, and gives a bouncing or elastic movement to the lever, and through that to the shutting valve; or a loose or damaged rubber seating may start it. The motion, being sympathetic, is repeated with greater velocity and intensity from valve to valve, till the noise becomes unbearable. The only remedy that the writer has found for it is to fix an air-vessel on the main service-pipe as near to the valves as possible, which will yield to the concussive rebound of the water when the valve closes suddenly. When the service-pipe to a valve water-closet is at a high pressure, and from too great a height, the closing valve will jump and raise a sharp hammering noise; the only cure for this is an air-vessel or an intermediate cistern fixed at a lower level.

Stopped Soil-pipe.—In the case of a stopped soil-pipe—if the trouble is in the water-closet trap—the stoppage may be removed or broken up and forced forwards with a drain-rod and a leather disc. If it is beyond the trap, the only way to clear it is to cut the pipe open vertically, and work it out sufficiently to get a cane or brush in to clear it. The pipe should then be carefully worked back, and the cut made good with a solder patch. Flannels and scrubbing-brushes are quite common articles found in water-closet traps, and it is always wise to look for them in the first place. Access-eyes and screws are a great convenience in the main soil-pipe, opposite the branches from water-closets and slop-sinks.

Patching a broken Basin.—Occasionally it is necessary to patch up a broken water-closet or lavatory basin till a new one is obtained. A fairly good job can be made by coating the edges of the broken ware with red-

lead paint, to which a quantity of gold-size has been added, and fitting them together. A piece of shaped strong muslin or scrimcloth is coated with thick red-lead paint, and pressed round the joined cracks; as the paint sets, it binds the pieces together and keeps the basin quite water-tight, and with careful usage may last a long time, but it can only be considered a makeshift till a new fitting can be procured. A similar method may be adopted for temporarily stopping cracks in lead gutters and the glass of top-lights.

Fixing Marble Tops to Basins.—In fixing marble tops to lavatory basins it has always been a difficult job to get a satisfactory joint between the earthenware and the marble. Some men use plaster of Paris, but this is not very satisfactory, as it may be washed out, and the soap then accumulates in the joint and causes a bad smell. Others bed them down with white-lead. If the marble is white the oil from the bedding soaks into it and makes an ugly stain, which it is practically impossible to extract. This bedding makes a sound water-tight joint, but unless the staining can be avoided, it cannot be used. If the marble is coated with shellac knotting, where the lead joint is to be, the oil will not stain to any appreciable extent, but the shellac surface must be quite hard and dry before the white-lead is applied. Another way of making this joint is with Keene's or Parian cement, but, though better than plaster, it is not quite satisfactory. The plumber must exercise his own judgment as to what is best to use.

CHAPTER VI

ORNAMENTAL LEAD-WORK

Lead has been used for many centuries for useful and decorative purposes, in the construction of church towers, flèches, gargoyles, cisterns, rain-water pipes, and spoutheads. During the Middle Ages its use was universal, and many quaint and artistic specimens are to be found throughout the country, which show that the craftsmen of those days thoroughly realized its adaptability for decoration, and also its durability. It is a matter for regret that modern utilitarianism has brought into common use inferior and less durable metals, like zinc and cast-iron. Little individuality can be found in the repetition of the standard patterns of the cast-iron foundry, and there is no scope for the development of invention or artistic treatment in the workman, who becomes a fitter instead of a manufacturer, and can have little of the pride of creative work so prominent in the mediæval artisan. The training of the modern plumber has been directed more in th[illegible]ion of sanitary work, and consequently the acquiremen[illegible] to manufacture lead in intricate and ornament[illegible] In large towns trade has been specialized, a[illegible]acquainted with one or two

branches of the craft and are practically useless at any other. The all-round trained mechanic has become scarce.

Of late years, thanks to the efforts of some of our architects and artists, there has been a considerable revival of the use of lead for decorative purposes, and the increased demand for it has caused special action to be taken by our technical schools for the purpose of training young plumbers in the art of lead-working. The methods and designs of mediæval plumbers are studied, the best of them adopted, and the inventive energy and skill of the students stimulated to new forms of beauty and design, and to improved methods of working.

Cast-lead.—Much of the old work is in cast-lead, and it is well for the modern plumber to understand the work of casting in its varied forms. A casting-frame, not less than 10 ft. by 3 ft., with the necessary sand bed, tilting-pan, strike, smoothing-plane, lead-pot, furnace, and ladles must be provided (Chapter II, pp. 55–56). The sand bed is prepared and made quite level and smooth, and the strike adjusted to the thickness of the sheet required. If the sheet is to have any ornament on it, as in fig. 84, or if a panel is wanted, or if it is to be cut up for making a decorated pipe, the pattern must be pressed into the surface of the sand bed in the position required. The patterns used may be a piece of wood moulding, a plaster cast, or a clay model, but must not be undercut or they will not draw from the sand without injury to the bed. The molten lead is then tilted from the hopper on to the sand, filling up the imprints, and the surplus lead is removed with the strike, leaving a sheet of lead of the required thickness with the design on it in low relief. The sheet is then removed from the frame preparatory to being cut up.

Fig. 84.—Cistern of Cast and Wrought Lead

In the case of a pipe, the lead is cut to the circumference of the pipe and dressed round a mandrel; the joint is then formed up the back by soldering or burning the edges together. The socket or faucet is cast separately, with ears for fastening to the walls, and soldered to the pipe; this is best done from the inside, so as not to show solder on the surface. In making up pipe from cast-lead, care should be taken not to injure the slightly-rough surface which is produced by the sand.

In whatever pattern panels are cast, they must be cut up and trimmed, bent to the shape required, and (if in a rain-water head or cistern) the different parts soldered at the angles, in every case on the inside. It is necessary to provide stiffening partitions inside all cisterns, so as to prevent bulging when filled with water.

Tools.—The cast sheets may be used for many purposes on roofs where the lead is to be worked or bossed. This can be done quite easily, the tools required being a pear-shaped mallet, wedges, punches, and dressers of various forms.

Flask Moulds.—In casting lead into forms that cannot be impressed into the sand bed, a flask mould is used. These are generally kept in different sizes to suit large or small patterns, and consist of two boxes without bottoms, and fitted face to face and kept in that position by round pegs. In use the pattern is placed on a flat board of the same size as the box, which is placed over it and filled up with the moulding-sand tightly rammed. Another board is placed on the box, which is turned over, exposing the pattern on the sand. The face of the mould is then trimmed up, so that the pattern will draw easily, and the surface is sprinkled over with fine burnt sand. The second box is fitted into the round peg-holes, and similarly filled with moulding-sand on the top of the pattern. The boxes are again turned over and lifted carefully apart, the layer of dry sand keeping them from adhering to each other. The pattern is gently tapped with a small mallet, so as to free it from the sand, and is then steadily lifted out. A channel is scooped out of the sand and carried through the mould, and another channel is cut for ventilation. The boxes are again fitted together and clamped, and the lead poured into one of the channel openings, filling up the mould, and expelling the air through the other channel. Thus almost any pattern can be cast, either as a whole, or in parts which can afterwards be fixed together.


Fig. 85.—Cast and Built-up Lead Vase

Working-up.—Lead is such a pliable metal that almost any shape can be cast on the flat with ornamental designs on it, and then bent and worked up into any form. Lead vases of very ornate appearance (fig. 85) are formed in this way, the body, the supporting foot, and the projecting handles being made separately, and fitted and soldered together with only the ordinary appliances of the plumber's shop. Cistern heads of any form and design can thus be built up, and als[illegible] and cresting, finials, turrets, gargoyles, crockets, friezes.

Dangers.—Great skill and i[illegible] king-up and fixing of lead, so that the st[illegible] ces copper

rods and stays are soldered inside cast-lead work to stiffen it, or in the case of ornamental cresting, where it might be liable to be bent over, a wrought-iron core is placed in the flask mould and cast inside the lead, thus securing the rigidity of the iron and the durability of the lead. As iron and lead in the presence of water are mutually destructive, they must be carefully protected from this danger.

Ornamental work in milled-lead requires more skill than in cast-lead, the forms and designs being beaten or bossed out. In the technical schools the student is generally taught to produce his own designs, and for this purpose has to take a few lessons in drawing. In the case of a panel (fig. 86) he draws out the design in chalk on the surface of the lead sheet. He then bosses the lead upwards with the round mallet till the sheet forms a hollow dome; then, with a rounded wedge formed of soft wood, and a mallet, he outlines the pattern on the surface of the dome, driving the surface of the metal downwards and inwards, leaving the pattern projecting beyond the surface. As he proceeds with this the lead gets gradually beaten down flat; he then raises it upwards, dressing out the pattern, gathering-in surplus metal from the outside, and working it into the pattern till it and the background are of equal thickness. The metal has to be carefully worked from both sides to produce good results.

Fig. 86.—Wrought-lead Panel

In some cases a wooden mould is carved out and the lead dressed over it. This is a much easier method, as any good lead-worker can manage it without any difficulty, but is much more expensive, unless a number of panels of the same design are required.

In covering turrets or finials it is best to avoid using solder, and the lead should be in small pieces and worked evenly in thickness throughout; and, if ornaments have to be produced on the surface, sufficient metal must be gathered-in to cover every part without stretching or weakening the surface. The bottom part of a finial should be first covered, the lead being cut out circular in form and bossed up into a cone shape. A hole is cut in the top of the cone, and this is slipped over the finial and dressed close into the different members, the bottom forming a flashing, covering the weathering of the roof. The upper portion of the finial may be covered from a circular piece of lead and similarly worked as the bottom, but it is easier to cut the lead in a strip form, a few inches wider than the widest member of the finial, and sufficiently long to fold over and

WORKING IN SHEET-LEAD

ORNAMENTAL PANEL IN WROUGHT LEAD:
FINISHING WITH MALLET AND WEDGE

COVERING A FINIAL WITH LEAD:
WELTED SEAMS USED AT SOME OF THE ANGLES

PLATE VII[B]

cover the whole of the wood-work. Commencing at the top, each side is worked downwards and inwards, the lead being worked into each member, till the whole is covered. The angles and arrises are kept of equal thickness, and chased-in so that the metal is everywhere in close contact with the wood. The upper lead is trimmed off so that it covers the bottom lead sufficiently to form a water-tight joint.

Ridging is sometimes made of an ornamental nature, the sides being cut to a scalloped pattern and an embossed design produced in each scallop. This has to be prepared on the bench. The lead is cut out sufficiently wide to cover the roll and give the lap on the roof. The design is drawn in chalk, and worked out with the mallet, wedges, and punches. The cut edges of the scallops are worked up to show the effect of a thick lead plate where it lies on the sloping roof. The lead is then bent at right angles, to a trough shape, the angle lying along the top of the ridge-roll. The trough is bent over the roll and the sides pressed on to the roof, and the lead is driven into the angles by means of a long chase-wedge.

Fig. 87.—Ornamental Lead-work on Flèche, Gordon's College, Aberdeen

Cresting for ridges and hips (fig. 87) is another and very durable form of ornament made from wrought and cast lead. It is made generally in two halves, hollow in shape, and soldered together. A wooden matrix is made of the desired pattern, into which the metal is dressed and trimmed flush with the surface; the edges are then prepared and strongly sweated with the copper-bit. Uprights at the end of each pattern are made in cast-lead, with an iron core, which is fastened through the ridge-roll, the hollowed lead being secured to the columns with decorated lead bands.

Decorative friezes are in some old churches fixed to the eaves under the overhanging gutters or under projecting gables; this form of ornament is occasionally used now, and affords a good deal of scope for the artistic workman. They are generally of a fretwork design, and may be cast or cut from sheet-lead. For making them, a hardwood bed, a set of shar- chisels and gouges, and several small rasps and files are the tools
The edges and perforations are neatly cut out, and the patte worked up in the manner already described.

Surface Soldering.—For decorating small articles manu such as vases, flower-stands, umbrella-stands, small lead

any vessel or decorative panel, surface soldering was at one time very common, especially in France. The effect is pretty and lasts a long time. The method of doing it is to draw the decoration on the finished article, and to carefully shave the surface and rub it over with powdered resin, and with a small copper soldering-bit run a body of very fine solder on the shaved surface. This looks easy, but is not so, as the solder must have its surface quite smooth, no joints showing. To attain proficiency in it the learner must first practise on a flat surface, till he has learnt to use the bit with skilful effect, and then gradually practise on circle and other work till he is able to produce any design that may be required. The old French lead-workers were very clever in this use of the copper-bit, and also in building up groups of ornament.

CHAPTER VII

LEAD-BURNING

Solder used for jointing lead is more or less liable to failure owing to the galvanic action set up between the two metals contained in the solder in the presence of moisture and acid. The affinity of the combination is thus destroyed, and corrosion ensues, causing leakage.

Jointing by Lead-burning.—For lead vessels that are to hold liquids it is best to boss up the material without seam, but, as this is not always practicable, the joints may be fused or melted together by the process of lead-burning. A powerful flame under pressure is directed on to the metal, a flux applied, and a seam formed of lead instead of solder. To do this successfully a special machine is required for compressed air, and a supply of hydrogen gas must be provided. This can be purchased in a compressed form in wrought-iron cylinders, the discharge from which is regulated by an air-tight tap at the outlet.

If it is considered best to manufacture the gas, an atmospheric air-pump (fig. 88) is necessary, consisting of a galvanized-iron cylinder, 4 ft. 6 in. high and 14 in. in diameter, divided into two compartments, A and B. The diaphragm C is formed of strong galvanized iron and securely soldered or riveted to the sides; from the upper part a pipe, D, 1¼ in. in diameter, is carried almost to the bottom of the lower chamber; the tap E is fixed for emptying the cylinder. From the top of the lower vessel a pipe is carried to the top of the machine, terminating with a full-way stop-cock, F, to which a flexible tube can be attached of sufficient length to reach the work to be done. The force-pump G is securely fixed to the side of the cylinder, and is used to keep up the supply of air. To charge the machine, water is poured into the upper vessel, and runs into the lower one, submerging the end of the pipe and imprisoning the air in the upper part. Sufficient water is poured in to compress the air, so that it may discharge with the required force to mix with the gas. The weight of water in the top vessel forms the forcing-power, while the used air is replaced by the force-pump.

The gas generator is built of strong timber, well jointed together and divided into three compartments (numbered 1, 2, and 3), the upper and lower being lined with sheet-lead, the angles being bossed up, and the necessary joints burned together, as solder would be useless owing to the acids used. A small lead box is fixed in the middle part, with a pipe and stop-cock (4) connecting it with the lower chamber. Access to these two parts is by large screw-caps (5) securely fixed and *soldered* to the lead lining. A pipe (6) is carried from the upper part through the middle to the bottom of the lower, and a loose perforated lead disc (7) placed about 1½ in. from the bottom, under which a screw-cap (8) is fixed for drawing

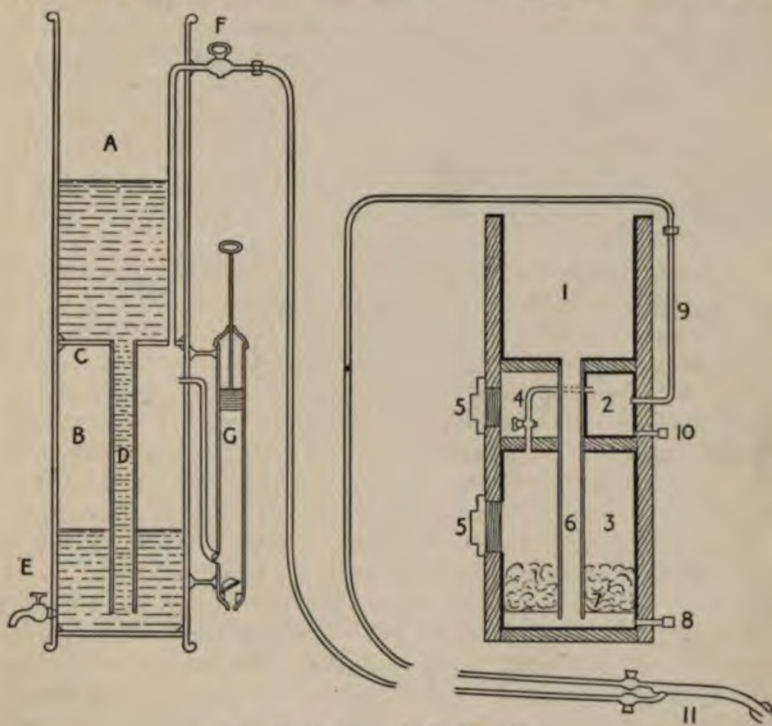

Fig. 88.—Apparatus for Lead-burning.

off the contents. From the lead box or gasometer (2) a discharge-pipe (9) is fixed, to which a flexible tube is connected and carried to the burner; a draw-off cap (10) is also fixed to this box for removing any condensed liquid that may accumulate. In charging the generator, zinc cuttings are placed on the lead disc and a mixture of water and sulphuric acid (H_2SO_4), in the proportion of two-thirds of water to one-third of acid, is poured into the upper chamber and runs into the lower chamber, sealing the end of the pipe and covering the zinc on the disc; hydrogen gas is thus generated in the lowest chamber, and can be admitted into the safety-box as required, by the pipe and stop-cock (4), and passes thence through the flexi
to the burner.

The junction of the gas- and air-tubes is by means o

to which the nozzle or burner (11) is attached, and a tap on each tube regulates the supply of gas or air. Nozzles of different sizes can be used, as required for light or heavy work. As the gas is generated it forces the liquid up the feed-pipe into the upper chamber, and when the valves are opened it escapes from the burner with considerable pressure.

In lining cisterns, sinks, or other vessels with lead, the seams of which are to be burned, there is not much difference from the methods used for soldering. Each seam should overlap, and as many of them as possible should be finished on the flat, as the operation is most easily done in that way. In the case of a cistern the bottom is placed-in first; the two ends are bent over an inch at the bottom and placed in position, showing a margin on the bottom; the sides are then cut out and a similar fold made at the bottom edge; the ends are cut to an angle and folded round so that the lap over the end lead is considerably wider at the bottom, and the seam runs diagonally. The advantage of this will be seen when the operation of burning is described. The edges of the lead are shaved perfectly clean and closely clipped together, so that they may not part when the heat is applied. A thin piece of sheet-lead cut in a strip is shaved clean and is used instead of solder.

The machine (both the air and the gas sections) is first charged and placed as near the work as convenient; the mate stands by the pump ready to replenish the air-pressure, while the plumber lights the gas at the nozzle and regulates it so that a properly-shaped flame is produced, the intensity of the heat being concentrated in the point. With the nozzle in one hand and the strip of lead in the other, he directs the flame to the seam and melts a small portion of the lead strip on to it, and fuses this to the seam, melting it and causing it to run together. Great care has to be taken by the workman in the management of the flame, as it is easy to melt too much at a time and leave holes. A series of pecking jets of flame causes the lead to run together, a solid and homogeneous seam being secured. It is comparatively easy to burn on the flat, as the metal does not so easily run away as in the case of an upright joining, where the melted metal is apt to run downwards without fusing the joint. To burn a vertical seam it is necessary to commence from the bottom, and melt a small quantity of metal from the strip and allow it to cool, forming a sort of shelf on which another portion of lead is melted into the seam, and so little by little the burning is carried up till the top is reached, the seam having a serrated appearance, showing on its front every separate operation. It helps the burner to have the seam fitted diagonally, giving a rest for each melted drop on the top edge of the joint. A skilful burner can, however, burn his seam quite vertically.

Patching.—In the case of a patch in any damaged vessel a hole is cut out and a piece of lead slipped in behind, and the lead round the hole dressed back over the patch, and the edge burned into the patch all the way round. It will be seen that the lead when melted naturally runs downward, so that the workman must always begin below his joint, and with his regulated flame cause the surface of the lead to run slightly downwards in the shape of a small bead, then from this he very carefully proceeds to build up to-

wards the joint, melting the lead as he goes, and feeding the stream from his strip of lead till he gets the joint at the patch complete.

Another method sometimes adopted for joining heavy lead generators for chemical use is to form them up in cast sheet-lead in a cylindrical shape, and then place them in a sand bed, leaving the seam exposed in a sand channel. The edges are cleaned and molten lead poured into this channel and allowed to run over the seam till it has fused the metal together by melting the lead on each side. The stream of molten lead is then stopped and the end of the channel blocked; the metal is allowed to cool, when the surplus can be cut off and the cylinder trimmed up. The ends are burned in a similar way. By these means a perfectly sound and reliable joint is obtained, and the bottom or top may be left of any thickness required. To do this successfully a good supply of molten lead well heated must be provided, the running metal being collected as it leaves the channel and transferred to the melting-pot at once.

Burned-in Flashings.—In fixing flashings to stone-work, where the courses are deep and long, chases are cut parallel to the upper edge of the upstand of the gutter, valley, or soaker, and 1 in. clear of them. They are generally cut 1 in. into the stone-work, the outer width of the chase being ¾ in., and the inner ½ in. wider. Into this the edge of the flashing is turned with a welt, which is opened out in the chase. The surface of the lead inside the chase is shaved clean and rubbed with tallow as a flux, and a mould of iron or other material is held in front of the joint, into which very hot molten lead is poured, filling up the chase. The molten lead attaches itself to the lead flashing, but contracts slightly on cooling, making it necessary to use a hammer and caulking-tool to drive the lead into the opening, so that a firm and weatherproof joint may be obtained. This method of fixing is neater and more reliable than fixing by wedge and mastic, or Portland cement. Its only drawback is its cost.

CHAPTER VIII

SOLDERS AND FLUXES

Solders are alloys formed from a combination of lead with tin in varied proportions according to the purpose for which the solder is to be used. Those in ordinary use are made in the following proportions:—

	Parts	Parts	Melting temperature
1. Best fine solder for silver and jewellers' work,	3 tin	1 lead	356° F.
2. Fine solder for blow-pipe work, ...	2 „	1 „	340° „
3. Copper-bit solder for brass, copper, &c., ...	1 „	1 „	370° „
4. Copper-bit solder for lead-pipe work, ...	1 „	1¼ „	390° „
5. Wiping or plumbers' solder, ...	1	2 „	441° „

In preparing plumbers' solder in [illegible] ·e-pot is necessary, and this must be kep [illegible] Pure

pig-lead is the best sort of lead to use, but where it is not available soft sheet or pipe scrap is best, as being most free from alloys. The lead should be melted into the pot first, and heated to a moderate heat, and then carefully skimmed. The tin is generally got in small ingots, with the "Lamb and Flag" mark of the Duchy of Cornwall stamped on them. The quantities must be carefully weighed before melting, so that the right proportion is obtained. After the whole is melted, the molten metals must be stirred and thoroughly mixed. A sample is taken from the pot in a small ladle, and a strip run out on a piece of clean stone, and a pat of the size of half a crown is also run out. On cooling, the strip should be of a pure white colour on the surface, with a number of bright spots spread over it; the pat should be of the same white colour with about three large bright spots. If the strip or cake has a number of crystalline marks over the white surface it denotes the presence of other metals such as zinc or antimony, both of which are fatal to the proper working of the solder. The solder is kept constantly mixed, and is poured by means of large ladles into cast-iron moulds, forming casts of ingots that can be broken from each other in pieces of 7 to 10 lb. each. The plumber should never use the metal in his pot to tin brass fittings, as these invariably contain zinc, but should use the copper-bit and fine solder. To make fine solder for using with the copper-bit or blow-lamp, it is not quite so necessary to insist on the purity of the metals.

To clean solder by extracting the foreign metals requires some little description. A very small proportion of zinc will prevent the solder from becoming plastic enough to wipe. Zinc melts at a temperature of 773° F., but becomes granulated at a much lower temperature, so that when solder is melted at 441° F. the zinc floats in a granulated state in the metal. To remove it the solder must be melted and at once taken off the fire, and, while cooling, a handful of powdered sulphur must be stirred into the pot, the metal being thoroughly mixed with the sulphur. The pot is again placed on the fire and heated; as it melts, the sulphur rises to the surface, carrying with it all the granulated particles of the unmelted zinc and antimony, and forms a hard crust which must be carefully removed (without breaking) with an iron trowel before the metal gets hot enough to ignite the sulphur. The result is that the solder becomes tractable and useful once more.

Fluxes.—For each solder a flux is necessary to form a medium to prevent the oxidation of the metals on the application of heat, and to assist the flow of the solder and its attachment to the surface of the metals joined. The fluxes are: (1) tallow, for wiping solder; (2) resin, for copper-bit solder on lead to brass, copper, or tin; (3) spirit of salt, which has been "killed" by the addition of a piece of zinc, for work on brass, copper, zinc, or iron. For blow-pipe work resin or salts may be used. Gallipoli oil may be used for pewter.

SECTION III.—SHEET-LEAD WORK

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SECTION III.—SHEET-LEAD WORK

CHAPTER I

GUTTERS AND CESSPOOLS

Superiority of Lead to other Metals.—It is often stated that modern plumbers have lost the art of sheet-lead working, and that it is useless to expect skilful and artistic workmanship of the kind with which our forefathers were familiar. One need have no hesitation in saying that this is a mistaken idea, and that lead-work of all kinds was never manipulated more skilfully than it is to-day. It is also said that the lack of skilfulness on the part of present-day plumbers has been the cause of the depression and even the disrepute of the craft, and of the introduction of zinc and iron and other substitutes which have been so extensively used during recent years. But the real cause is that these materials are cheaper, so far as the first cost is concerned, and do not require such substantial timber-work and supports as the heavier metal. Time, however, has proved that most of the metals which have been used in the place of lead are more expensive in the long run, because of the more frequent renewals which are necessary. The result is that lead is again being used for purposes for which it was regarded, many years ago, as indispensable. Its durability, when properly used, its adaptability in nearly all cases, and the artistic treatment to which it lends itself render its general use for roofing purposes, where sheet-metal of a substantial character is required, almost a necessity.

Iron has been used to a very large extent as a substitute for lead for rain-water heads and pipes, and also for parapet and other forms of gutters; but during the last few years there is a decided revival in the use of lead for these purposes. Many architects are recognizing the advantages of cast- and sheet-lead for heads and rain-water pipes, since it has been found that cast-iron pipes soon rust away, and in many cases have ruined valuable buildings by leakages, the water from which has soaked through external walls, whereas they have ample evidence of the durability of lead on many of the ancient buildings where lead heads and rain-water pipes have endured for centuries, and have retained their artistic appearance without the aid of paint or any other preservative. This is more especially the case where cast-sheet lead has been used, because this is not only more durable, owing to the property it has of resisting the expansion

and contraction caused by variations of temperature, but it has a more artistic appearance, than the modern milled-sheet lead. Fortunately, these advantages are being recognized by many modern architects, and the old casting-bench is to some extent being reconstituted.

Sheet-lead casting is one of the things that, it is said, modern plumbers cannot do, but this is quite a mistake, for recently the writer saw some sheet-lead cast quite as true and even in thickness as any to be found on the roofs of ancient mansions or churches.

Cast and Milled Lead Compared.—The cost of cast-sheet lead is, however, considerably more than that of milled-sheet lead, and this is the reason why it is not used more extensively. If the lead is not cast skilfully, it has the disadvantage of being very uneven in thickness, and numerous sand-holes may be found in it; and if it is not cast at the right heat it is not homogeneous, and will not bear the bossing which is generally necessary in external lead-work.

As a matter of fact, in old cast-sheet lead work it is very rare that one finds the finished workmanship that is now put into milled-sheet lead work. When this class of lead is pure and well milled, the enormous pressure to which it is subjected in its manufacture has very little detrimental effect on its working properties, although it has a tendency to prevent the free expansion and contraction which must take place under the action of cold and heat. The durability of cast-sheet lead, although to a large extent due to the natural conditions under which it is made, also depends in a very large measure on the purity of the metal. The impurity of the metal is also often the cause of failure in modern milled-sheet lead.

Cast-sheet lead is sometimes used because it is possible to recast old lead on the spot. This is often done where the lead roofing has to be renewed on old churches, and when they are situated in remote places there may be considerable economy in re-using the old lead, instead of sending it away and bringing new lead to replace it.

Dimensions of Sheets.—Cast-lead sheets are made to various dimensions to suit the circumstances. The casting-bench is therefore made of any convenient size, but it does not often exceed 20 ft. by 6 ft. Milled lead is made into sheets approximately 32 ft. by 7 ft., but sometimes as wide as 9 ft. The thickness is regulated by the weight per square foot; a weight of 1 lb. will make a sheet 1 ft. square, with a thickness of ·017 in., or, in vulgar fractions, $\frac{1}{60}$ in. From the thickness per pound the thickness of any weight of lead can be found by multiplying ·017 by the weight per foot. Thus "5-lb. lead" is $\cdot 017 \times 5 = \cdot 085$ in. thick. The usual weights for roofing purposes range from 4 lb. to 8 lb. per square foot, but in some cases 10-lb. lead is used for gutters and flats.

The Wood-work.—The durability of sheet-lead depends very much on the way the timber-work is prepared, and also on the way the lead is arranged and worked. The wood-work should be substantial, and have a regular surface. It is a mistake to suppose that wood-work similar to that prepared for zinc is suitable for lead. It is true, of course, that any metal covering is all the better for a good foundation; but lead, being a comparatively soft metal, requires a sound and smooth surface to lie on, if it is to

be used to the best advantage. All boarding under the lead should be laid in the same direction as the fall of the gutter or flat, and not at right angles to it. Many carpenters, or their employers, adopt the latter arrangement for the sake of economy; but in some cases, if the details of the timber-work are properly considered, it costs no more to do it right than to do it wrong.

Size of Pieces.—Another important point concerns the dimensions of the pieces of lead used for gutters, flats, and other purposes. The general rule is that gutters and the bays on flats should not be more than 10 ft. long, irrespective of the width, and no doubt this rule is found to be fairly convenient. But if the sizes of the pieces were determined solely with a view to their durability, they should be as nearly as possible equal in length and width. This, however, would not always be practicable; in gutters, for instance, to carry out this rule it would be necessary to construct drips in about every 3 ft. of the length, and such an arrangement would, generally, be out of the question.

The 10-ft. length must, however, be regarded as the maximum, which must be reduced wherever possible; because when a long and narrow piece of lead is laid in a position where it is exposed to the sun's rays for any length of time, the longitudinal expansion is out of all proportion to the expansion across the width. Therefore a fracture is bound to take place sooner or later, according to the degree of variation of temperature. But when the length approximates to the width, the expansion and contraction are more likely to be equal in both directions, with the result that it will resist fracture for a much longer time. This is more especially the case with modern milled-sheet lead.

Soldering.—Another point is that sheet-lead work on roofs should be free, as far as possible, from soldered seams, for the reason that the solder does not allow the lead to expand and contract freely. There are exceptions to this rule, when large pieces of lead are not involved, as will be shown later on. But when long pieces of lead are soldered together, a fracture is sure to occur, in a very short time, close to the soldering. This is frequently seen when a shallow drip has been soldered, or when a seam is wiped across a fracture in the middle of a gutter; either the lead close to the edge of the solder cracks, or the soldered seam breaks along the centre.

The soldering of a drip is often done on account of the improper construction of the drip in the first instance. Either the drip is too shallow, and the water rises up between the laps by capillary attraction, or the undercloak is broken, and allows the water to leak into the roof.

The Drips.—In the parapet-gutter shown in fig. 89 there are three drips, because the whole length of the gutter is about 25 ft. As shown in the longitudinal section, the drips form steps in the length of the gutter, and are placed, as nearly as practicable, an equal distance apart. They should not be less than 2 in. deep; it is found by experience that this depth is sufficient to resist the capillary action, provi[illegible] [illegible]aken vertically.

In this case the gutter is shown p[illegible]

to the rain-water head. This is not the best way of discharging the water, but, as it is often required, it may be well to deal with it first. The width

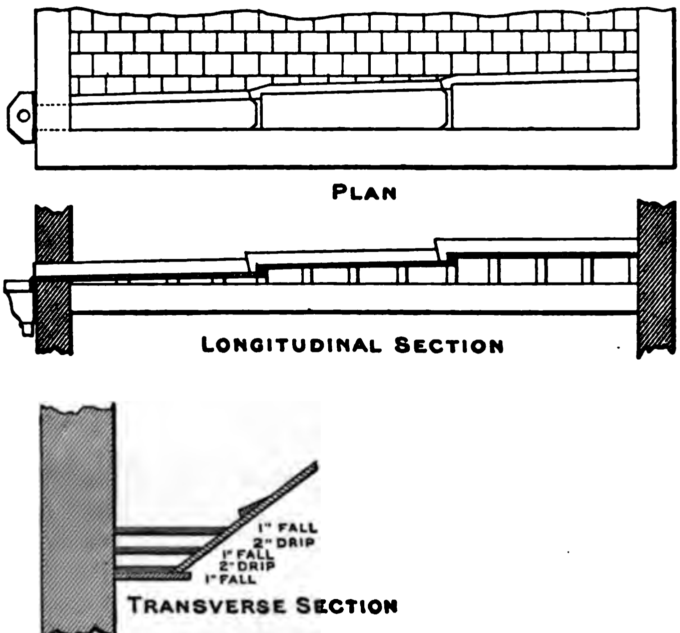


Fig. 89.—Plan and Sections of Parapet-gutter

of the lower end of the sole of the gutter will be taken as 1 ft., and as the gutter rises, on account of the fall and the drips, it becomes much wider at the upper end, the increase depending on the slope of the roof. The usual fall given to a gutter between the drips is 1 in., or a little more or less, in 10 ft. This is shown, together with the drips, in the transverse section (fig. 89).

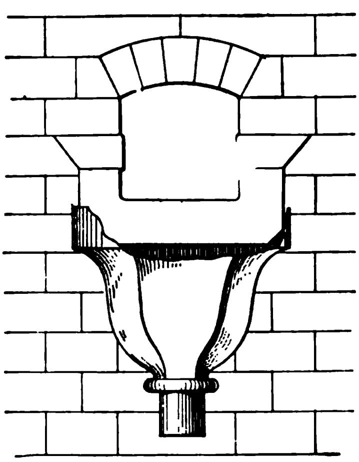


Fig. 90.—End of Gutter discharging into Rainwater-head

The "Fall".—It may be well to state here that it is not advisable to give the gutter more fall than is really necessary to drain it; because, when more fall is given, the lead is likely to creep downwards, and thus get out of place. To prevent the downward movement it would be necessary to provide some special fixing, but these should only be made use of when it is absolutely necessary to fix the lead on a considerable slope. These fixings will be explained later.

The outlet of the gutter is often very improperly allowed to project out over the head, with the edges of the lead exposed, but this is a very slovenly job. The best plan is to boss the sides round on the face of the wall, and

run the flashing out to the extreme edge, as shown in fig. 90. It will be noticed also that an arch is turned over the outlet, instead of having a square hole with a piece of slate inserted as a lintel, to support the bricks above.

The Various Forms of Drip.—The next thing to consider is the section of the drips. The sectional view at A (fig. 91) shows an ordinary form of drip, where the overcloak is worked down on the sole of the lower gutter, and trimmed off about $1\frac{1}{4}$ in. from the angle. There are some who object to this method of finishing a drip, because, it is said, capillary attraction is caused when the overcloak is lying on the bottom of the gutter. Capillary attraction is so well known that it is hardly necessary to give any detailed description of it, but it may be pointed out that experiments with sheets of glass, or capillary tubes, will not exactly determine the limits of the force in practical plumbers' work. Experience has shown that, when a drip is at least 2 in. deep, there need be no fear, under ordinary circumstances, of leakages occurring from this cause. And when the drip has the required depth, the mere fact of an extra lap on the bottom of the gutter does not affect the question of capillary attraction.

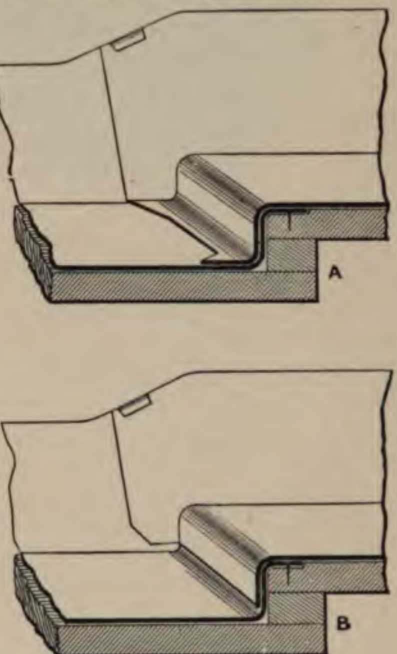


Fig. 91.—Two Forms of Drip in Gutters

When the lead is trimmed off in the manner shown at B, fig. 91, the overcloak will in a very short time become loose, and leave an open space between it and the undercloak. The result, in many cases, is that when the rain is blown in that direction the water is driven up under the lap, and then, assisted by the capillary action, the rain soaks under the gutter, and will at any rate rot the timbers, even if it does not show inside the building.


Fig. 92.—Splayed Drip in Gutter

Some plumbers have an idea that a splayed drip like that shown in fig. 92 can be made to a less depth because the lap is increased by the shape of the drip. But this is a mistake. The safe [illegible] sured vertically, and no extent of splay will [illegible] the vertical section is below the limit. The [illegible] of this form of drip is that it is more e[illegible]

so much labour saved as is generally supposed. The bossing is certainly easier, as it is spread over a larger space, and there is not so much fear of distressing and breaking the lead. The lead, however, does not remain so tight as it does on a square drip, the result being that the dirt gets under the lap. There can be no doubt that, when the square drips are skilfully bossed, they are much more satisfactory, and tend to make a more permanent job.

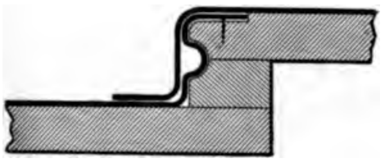


Fig. 93.—Gutter-drip with Capillary Groove

There are cases, however, where it is not possible to obtain a 2-in. drip, and the force of capillary attraction must then be arrested by what is known as a "capillary groove", which consists of a horizontal groove cut in the front of the drip, as shown in fig. 93. The undercloak is worked into this with a chase-wedge, and the overcloak is bossed over it in the usual way. As capillary attraction depends on the two surfaces being in nearly close contact, it is obvious that the water in this case would not rise above the lower edge of the groove. Drips only 1½ in. in depth may be constructed in this way with safety, but it is, of course, not advisable to make a drip so shallow when it can be avoided.

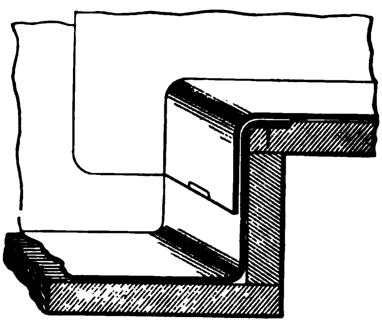


Fig. 94.—Gutter-drip into Cesspool

Although the deeper the drip is the better, it does not follow that the overcloak should trim on to the bottom gutter in all cases. Where gutters discharge into a cesspool, for instance, as in fig. 94, they are quite water-tight if they are worked down 3 in. in depth, but an improvement is made by securing the bottom edge by a sheet-copper tack, as shown in the sketch. This is fastened with copper nails close to the edge of the drip, and turned up over the dripping edge about ½ in.

Cutting Out and Setting Up.—The general design of the work having been decided, the cutting out and setting up of the lead should now be considered.

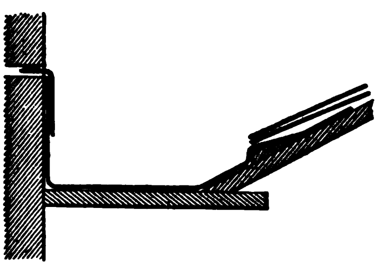


Fig. 95.—Cross-section of Gutter

A parapet-gutter of the kind we have in hand is one of the simplest forms for bossing. The first thing to do is to measure the gutter accurately, and cut the lead accordingly. The widths of gutters vary, but the usual rule is for the lead to stand up against the wall 6 in., and on the other side it should be 4 in. to the springing or tilting fillet, and 6 in. under the slates. Sometimes the springing is kept 6 in. from the sole of the gutter, and in some cases it is as low as 2 in.; but a height of 3 in. or 4 in. is the most suitable in ordinary cases. Some plumbers contend that there is no need to take the lead under

the slates any more than the usual horizontal weathering or lap of the slates, which averages about 3 in.; but as the springing is apt to throw the water back, as shown in fig. 95, especially on low-pitched roofs, it is necessary to make the minimum height 6 in.

"**Distressing.**"—In working sheet-lead care must be taken to prevent what is called "distressing" of the metal by the improper use of the tools. When preparing the lead, the dressers and chase-wedges should not have sharp edges, but be well rounded to a radius of not less than $\frac{3}{8}$ in.; some, indeed, particularly chase-wedges, should have edges made to a larger radius. It is only when the finishing strokes are given that tools with sharper edges should be used.

Setting-in the Angles.—After the angles, on the roof and parapet sides, and also the line of the drip, have been set out with a chalk line, the sides should be pulled up against a piece of straight timber in the manner shown at A, fig. 96, and the angles set-in by means of a hornbeam dresser and large mallet or hammer, as shown at B. While this is being done (or in any case where the lead is being set-in), the plumber's mate should hold down firmly on the edge of the turn-up, and follow the blows of the hammer and dresser. This presses the angle down on the flat surface, such as the floor or bench, and prevents the stretching of the lead at the angles. Some plumbers attempt to set-up lead in the same way as they do zinc, by dressing it over the edge of a plank, but this is a very unsuitable method. Lead should always be set-in from the inside, and any dressing-up that may be required outside should be done afterwards.

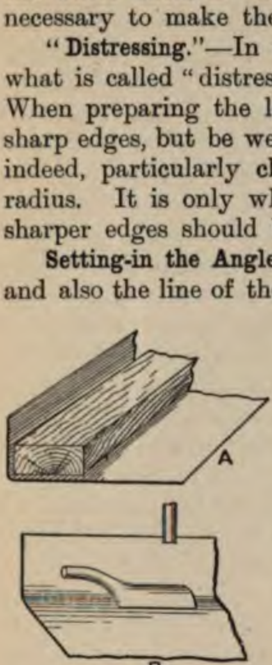


Fig. 96.—Method of Working the Upstand of a Gutter

Bossing the Corners.—The first corners that have to be bossed are those for the undercloak of the first drip; these are only 2 in. high and have to be worked in the manner shown at A (fig. 97), which gives a view of the end of the gutter turned up, so as to make it convenient for bossing. B shows the un
in its place, with the clout or copper nails driven into the
In setting-in the angles in their position, the same proc
for setting-up the angles should be employed. For

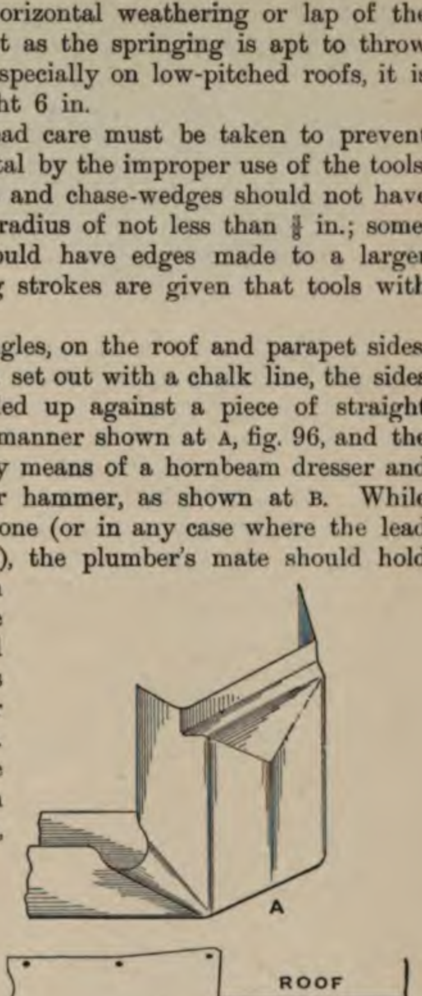


Fig. 97.—Undercloak of the Drip

hold down firmly, while one end of the gutter is being set-in, the other end will rise out of its place. Careful holding down is important in good sheet-lead work.

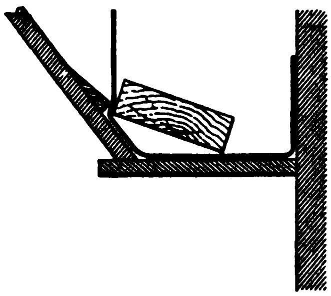


Fig. 98.—Method of Setting-in the Springing

Setting-in the Springing.—With regard to the setting-in of the springing, the lead should first be broken-in to the shape by placing the edge of a long piece of timber to the line forming the internal angle of the springing, as shown in fig. 98. If the plumber and his mate kneel on the timber, and with both hands bend the top edge of the lead backwards and forwards, the lead will take the form of the springing, and will require but very little setting-in afterwards. It is necessary to explain this simple process, because there are many plumbers who try to set-in the springing by means of the hammer and dresser only, with the results that the angle is far from straight, a bad finish is given to the work, and the lead is often distressed by the effort to set it up into the internal angle. A few copper nails or iron clouts should be driven through the top edge into the roof-boards, to keep it in its place, before the lower end of the gutter is bossed down into the head or cesspool.

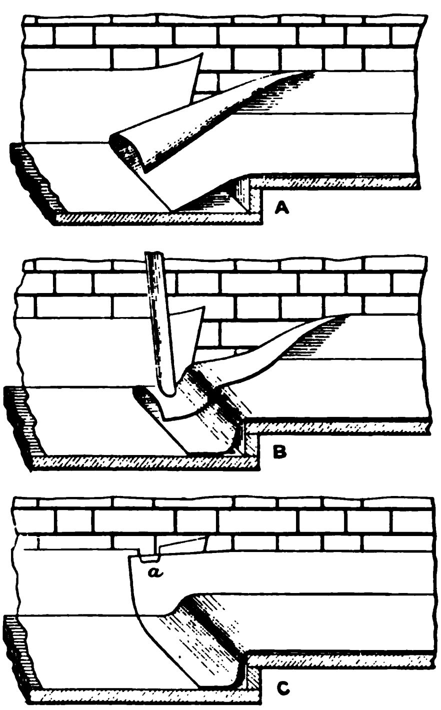


Fig. 99.—Method of Working the Overcloak of the Drip

Working down the Overcloak.—The usual way of working down the overcloak of the drip is to drive-in the lead from the end of the gutter, and thus form a lump, which provides sufficient metal to enable the angles to be driven-in tight and thick by means of chase-wedges. In many cases, however, this plan results in failure; either the lead is distressed, until it is like a piece of paper, or it is badly split and some botching work has to be done in order to hide the defect.

It is much better that the lead required for bossing into the angle of the drip, instead of being forced in or stretched out of the part which is turned down into the lower gutter, should be obtained from the turn-up against the wall or under the slates, where a little thinning of the metal is of no consequence, because it is covered by the flashing or slates, and is not exposed to the weather. The sketches in fig. 99 show the process. The first thing to do, after

the gutter is well in its place, is to turn down one side as shown at A. No attempt should be made at first to boss this down, but it should be turned over by bending, and then the part which lies over the drip should receive a sharp blow with a large hammer on a soft piece of wood, as shown at B. The mate should now hold down tightly with his holding-down stick, on the point where the blow has been struck, and the edge of the turn-up should be stretched back to its place in the manner shown at C. It will be found that the drip has been driven partly home without the slightest thinning of the lead. If, indeed, the work is done carefully, the lead is made thicker in the drip.

Wrinkles.—It is not practicable to work the overcloak down in one operation, and it is not wise to try to do so. The process should be repeated two or three times, as this will not only enable the plumber to boss the lead down without wrinkles and kinks, but it will be found in the end that the work is done more quickly. There is, of course, a tendency to form wrinkles on the stand-up near the edge of the drip; these should be observed, and dressed out by placing a steel plate between the lead and the wall, in order to give a hard level face for dressing.

Finishing the Angles.—After the drip has been roughly got home on both sides by this process, the chase-wedges are used to finish off the angles, which need not be sharp, but rounded to a good radius.

The turn-ups on the wall-side should now be tacked together, as shown at *a* (fig. 99, C), by forming a tack on the undercloak and turning it over on the overcloak; this holds the two gutters firmly together.

Upper End of Gutter.—The next point is the upper end of the gutter, which is shown at A, fig. 100. This consists of a vertical corner and a splayed angle up the roof. B shows the setting-out of the end, and the amount of lead which has to be cut out before bossing.

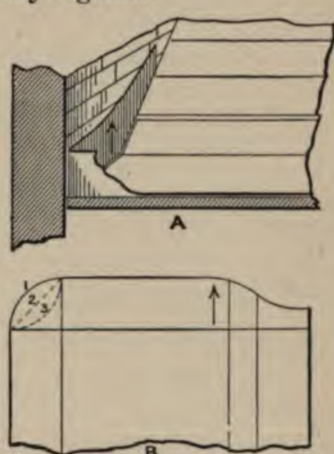


Fig. 100.—Upper End of Parapet-gutter

It is well to remember that in bossing up the corner of a gutter, or any other piece of sheet-lead, it is necessary, in order to obtain an equal thickness of metal, to cut out or boss out some of the lead. In this case the surplus metal is equal to 6 in. square. If the corner is to be bossed up with as little labour as possible, most of the surplus lead should be cut out before the bossing is started. Some are content to cut the lead at the curved line 1, but a more skilful plumber will cut it to a straight line 2, while others will venture to cut it as close as that shown at 3. In any case, whatever portion is cut out at the start, the whole of the surplus metal should be worked out in the process of bossing, so that no part of the finished lead is thicker than another.

The bossing of the splayed angle up the roof should be done in t tion shown by the arrow (fig. 100, A), and not up the angle whi the roof, as is very often done, for by the method advised, t

angle requires only about half the labour required for the upright corner, whereas by the improper method it requires nearly twice as much.

The weight of the flashing from the wall into the gutter should be somewhat less than the weight of the gutter, but in any case it should not be less than 5 lb. to the square foot. It should turn into the joint of the brickwork just above the top edge of the gutter, and lap over on an average about 2½ in. The bottom edge of the flashing should be parallel to the sole of the gutter and be tacked with what are called "bale tacks". These consist of strips of lead, 2 in. to 3 in. wide, and long enough to clip over the edge of the gutter, and turn up over the lower edge of the flashing, as shown at *a*, fig. 101.

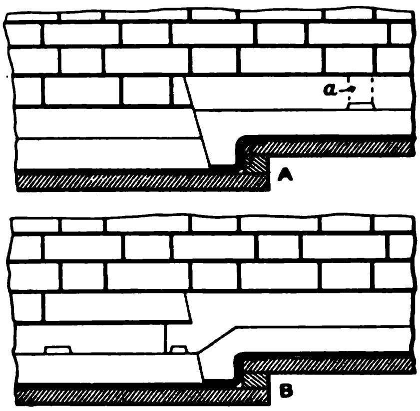


Fig. 101.—Flashings of Gutter

Method of Forming Lap.—Fig. 101, A, also shows one method of forming the lap at the drips. The lower flashing is taken behind the vertical lap of the gutter, and the flashing on the upper gutter finishes at the same lap, but a small tack or lug is turned behind the lap in order to keep it back in its place. The sketch at B shows another way of arranging the flashing at this point. In this case the lead is cut in the form of what is called a "gun-stock" and is carried over the vertical lap of the gutter as shown.

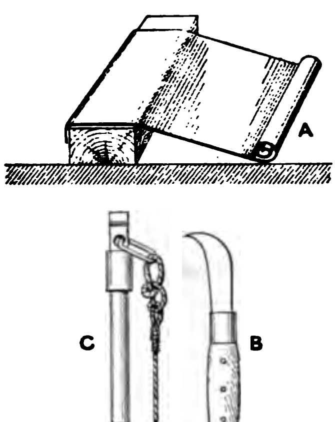


Fig. 102.—How to Cut Lead Flashings

To Prepare Flashing.—It is most convenient to cut straight flashing in 7-ft. lengths, that is to say, across the width of a sheet of lead. Each length should have its own tack, which should be left on the underlap and turned over the edge of the overlap as shown at B. The best way to prepare flashing is to turn the 1-in. edge, for fixing in the joint of the brickwork, over the edge of a plank, and cut the piece off afterwards, as indicated at A, fig. 102. A line should be struck with a chalk-line, and the cut should be perfectly straight. This can be done with a strong stiff-handled knife like that shown at B, or, better still, with a long lead-knife similar to that shown at C, formed with a square-ended blade let into an iron or brass socket having a handle about 4 ft. long. The blade is provided with a hole in the centre, through which is placed an iron link. To this is attached a strong cord and a beech or other hardwood cross-bar handle. After a little practice the plumber can cut to a straight line quite easily, while the mate pulls the knife along by the cord and handle. Another advantage of the long knife is

that the lead is cut clean and completely through, and there is no need to put the length of flashing out of shape by bending it about in breaking it off the sheet.

The fastening of the flashing in the joints of the brickwork is another important item. Years ago it was the custom to drive ordinary iron wall-hooks into the joints, with the heads of the hooks over the front of the flashing. This is not only a waste of good iron, but is not nearly so effectual as some simple form of wedge, either of wood or lead. Another method of fixing is the operation known as "burning-in", but this is only suitable when lead is burned into a joint in stonework. In ordinary stock-brick work the wooden wedges should not be very hard, as the driving of them is likely to burst off the edges of the bricks. But when the walls are built of good sound hard bricks, oak wedges are more suitable, although lead wedges are much the best, if the brick or stonework is substantial. The lead wedges should always be cast, not formed of narrow strips of lead rolled up into a lump and driven into the joints, as is very often done as a make-shift.

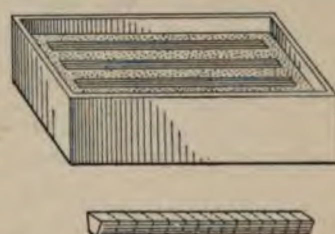


Fig. 103.—Method of Casting Lead Wedges

There are two ways in which the wedges can be cast. One is to cut the ends of three or four sticks to form patterns for wedges of various sizes, and to make impressions with these in a bed of sand, into which the molten lead is poured. Another way is to make patterns about a foot long, with a sectional area of the required sizes of the wedges, and cast the lead in strips as indicated in fig. 103, where a sand-box and pattern are shown. They are then cut or sawn into the lengths for wedges.

The next point is that the wedges, whether wood or lead, should be driven into the joints by means of a wedge-punch, which may consist of a kind of chisel with a square end, just wide enough to pass into the joints. With the aid of a hammer the wedge is driven in about ¼ in. inside the face of the brickwork, so that the cement pointing will completely cover it. This is most important in the case of wooden wedges, because they must be protected from the weather. Considerable damage may be done to the wall by driving the wedges in too tight; especially is this the case with lead wedges, as they will expand in width while they are being driven from the front, and so burst the bricks.

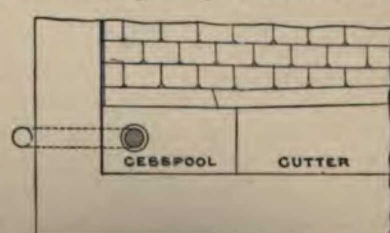


Fig. 104.—Plan of Cesspool

Cesspool.—The plan of the gutter, fig. 89, shows a head, into which the gutter is turned, but a better method, and one which is generally adopted on first-rate jobs, is to form what is known as a "cesspool" at the end of the gutter, a[illegible] om this cesspool a lead socket-pipe is taken th[illegible] n head, or direct to the rainwater pipe.

The cesspool should not be less than [illegible]

the lead forming the sides and ends against the parapet should finish at the same height as the top edge of the gutter. As a rule the lead for the cesspool is in one piece, and the angles are cut out and soldered. This is one of the exceptions to the rule that no solder should be used in lead roof-work. The reason in this case is that the piece of lead is comparatively small, and the objections to solder do not apply very forcibly, as the cesspool is self-contained and is not soldered to any other part of the lead-work, except the socket-pipe. Another reason is that generally two of the angles are a foot deep, and it is not thought worth while to expend the necessary labour on bossing up such deep corners, when they can be cut and soldered in less time, and (as experience has proved) with satisfactory results.

Fig. 105 shows a longitudinal section of a cesspool suitable for a parapet-gutter. The socket-pipe is also shown passing through the wall to the rainwater head. In this case the outlet is in the bottom, and the socket-pipe is connected

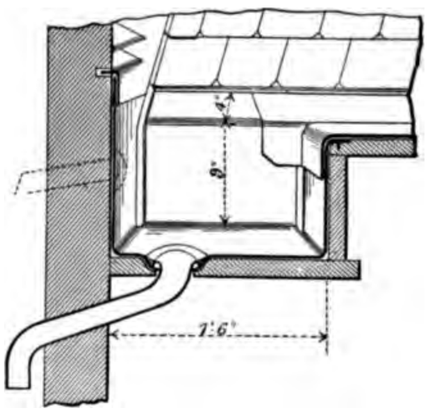


Fig. 105.—Longitudinal Section of Cesspool

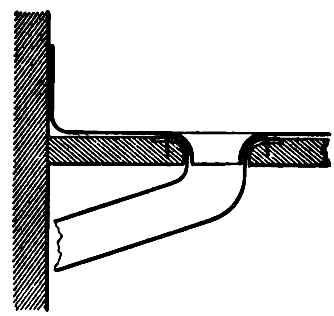


Fig. 106.—Socketed Outlet of Cesspool

by a wiped joint. In some parts of the country it is the custom merely to boss the lead, at the bottom of the cesspool, down as far as it will go into the end of the socket-pipe; this is probably the reason why it is called a socket-pipe, because the pipe forms a socket and the cesspool bottom a spigot, as shown in fig. 106. It is a method, however, which cannot be regarded as satisfactory, for in many cases the spigot is too short, and is often split, and if it is bossed down a reasonable depth it is not safe, because, if the pipe should become stopped (by a bird's nest, for example), the water will easily find its way through the joint into the roof.

The wiped joint is the proper device to adopt, and, as an extra precaution, an overflow-pipe should be taken from the cesspool, just below the level of the gutter-drip, through the wall, so that in case of a stoppage occurring there is no fear of the water getting under the lap of the gutter. This is shown by dotted lines in fig. 105.

The way to cut out the lead for a simple cesspool and prepare it for soldering is shown in fig. 107. On comparing the figured dimensions, the sketch will explain itself. A more difficult one is shown in fig. 108. The plan should first be drawn on the piece of sheet-lead, and then the sides and ends developed in the manner shown in the sketch. It will be

noticed that the cesspool has a splayed end, and also a break in one of the sides. Although there are six angles on the plan, only four must be soldered; the other two are folded at the dotted lines to the shape required, but a part of the bottom angle has to be soldered. The break is often regarded as a difficulty, and some plumbers consider that it must necessarily be bossed; but if soldering is admissible at all there is no reason why it should not be treated as shown in the sketch.

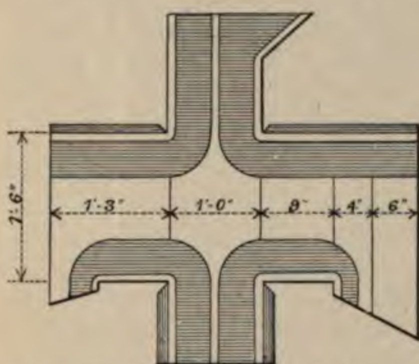


Fig. 107.—Method of Cutting the Lead for a Simple Cesspool

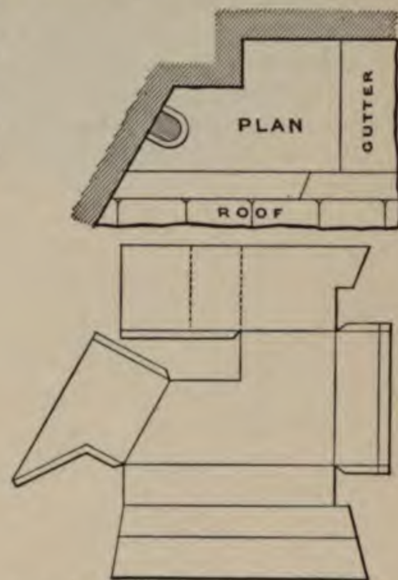


Fig. 108.—Plan of Cesspool with "Break", and Method of Cutting the Lead

"Bird's-mouth" Socket-pipe.—The socket-pipe in this case is arranged differently, and the connection is known as a "bird's-mouth" (see fig. 109). This is sometimes done from necessity, because there is no room for a bend below the bottom, either on account of some obstruction or because the socket-pipe has to be kept up to a high level. Sometimes the "bird's-mouth" is adopted of choice, as it is possible in this way to dispense with bends, and allow the socket-pipe to shoot straight into the head. It is, however, a much better job to form a slight bend on the end, so that the water falls vertically into the head.

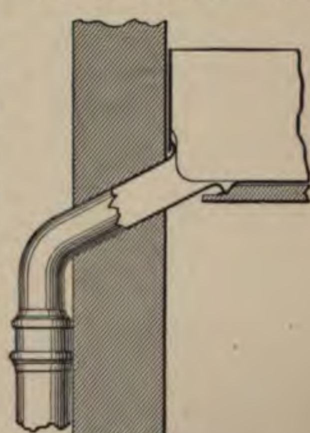


Fig. 109.—Bird's-mouth Socket-pipe connected to Rainwater Pipe

The Head.—In some cases no head is used at all, the end of the socket-pipe being made to enter the socket of the rainwater pipe, as shown in fig. 109, and, as a matter of fact, if an overflow-pipe is fixed to the cesspool, as shown in fig. 105, the head is quite unnecessary where appearance is not taken into consideration. Most people prefer a rainwater head, as it makes a better finish to the rainwater pipe, and where no overflow-pipe is fixed to the cesspool the head acts as a safety ou in case of a stoppage in the rainwater pipe.

CHAPTER II

"BREAKS" IN LEAD-WORK

Ancient and Modern Bossing.—In addition to the ordinary corner, or internal angle, it is very often necessary to work what are known as "breaks", or external angles, where set-offs are formed in the walls by the side of the gutters. Such an angle is shown in fig. 110. The bossing in this case, it will be noted, is quite different from that of an ordinary corner, because, instead of working or bossing out surplus metal, it is necessary to provide some from an adjoining part of the piece. And this is one of the examples which show the peculiar character of lead, for there is no other metal which can be manipulated exactly in the same way. In most old lead-work the breaks are not to be compared with modern bossing. This is sometimes attributed to the rough character of the old cast-sheet lead, but there can be no doubt that the art of bossing lead has much improved during recent years, and the "break" of equal thickness throughout is now the rule and not the exception.

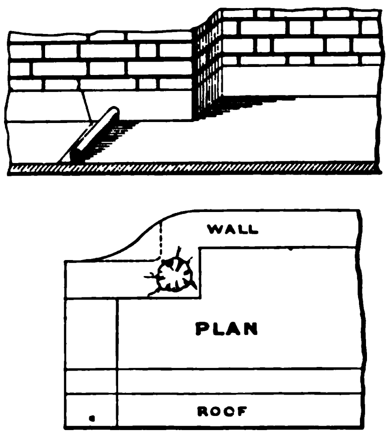


Fig. 110.—Break in Lead Gutter

Preparing a Break.—In the case of the break in fig. 110, where there is an internal corner to be bossed up within a few inches, the work becomes comparatively simple. It is when the break is some distance from the corner, like that shown in fig. 113, that more difficulty is experienced. In the former case the lead is set out as shown in the plan, care being taken to leave a reasonable amount of lead against the break in order to facilitate the bossing. If the lead were cut to the dotted lines, there would be sufficient for the turn-up, supposing the whole of the surplus from the corner could be worked into the break, but this would not be practicable. It is therefore necessary to leave an extra width against the break, as shown, as a means of conveyance, as it were, from the corner to the break.

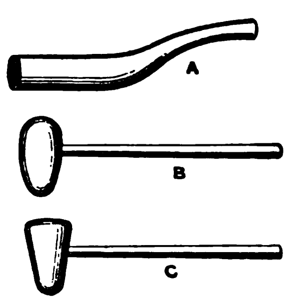


Fig. 111.—Bossing-stick and Mallets

Tools.—With regard to the tools for this work, it is always advisable for beginners to start with a box-wood bossing-stick of the kind shown in fig. 111, A; because, although the work may be done more quickly by the aid of a bossing-mallet, it certainly cannot be done so neatly and safely by those who are not yet skilful. When a mallet is used, it should not have a rounded face like B, but a nearly flat face with well-rounded edges like C. The reason is that a rounded face stretches and weakens the lead,

and does not drive it from one point to another as is required, whereas the flat face enables one to draw and drive the material in any direction.

Bossing a Break.—When the break at fig. 110 is set up, and the bottom angles formed by the edge of a hornbeam dresser and blunt chase-wedge, the corner should be started in the ordinary way, by first working downwards towards the lower angle and there forming a lump, which should not be disturbed until the bossing is nearly finished. The bossing should proceed in an upward direction with a tendency towards the break, and, after the lower parts of both are fairly well formed, the whole of the bossing from the corner should be directed into the break. At the same time, the outer edge of the lead opposite the break should be driven inwards with the object of thickening it, and should also be turned over towards the angle of the break. This method of working has the effect of forming a rough lump at the spot shown on the plan, and this should be preserved until the break is nearly back to its proper position, when the surplus in the lump can be used for thickening the external angle.

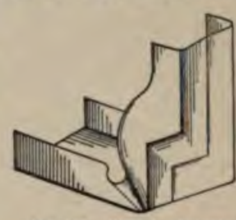


Fig. 112.—Sketch of Gutter with "Bellied" Bottom, turned up for Bossing a Break.

During the process the gutter should be frequently bumped on the floor for the purpose of straightening the lower angles, otherwise they will get out of shape, and, if left too long, they cannot be put in proper order. The shape is, however, retained to a large extent by careful setting-up in the first place, and by the bottom of the gutter being "bellied", as shown in the sketch, fig. 112, where the end of the gutter is turned up in a convenient position for bossing the break. The bellying is done by forming a ridge along the centre of the gutter by means of the side of a large mallet, although just against the break this ridge should not be too prominent, because the working of the break has a tendency to drive the side of the gutter in, and the ridge or bellying at this point becomes a buckle.

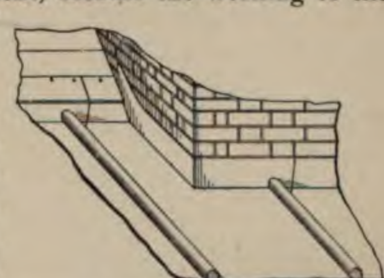


Fig. 113.—Break in Lead Flat

In the case of fig. 113 the whole of the lead required for the break has to be bossed-in, principally from the outside edge, but partly from the adjoining sides. Consequently, when the lead is cut out, a more than usually wide margin is left on opposite the break. In this form of break there is considerable difficulty in preventing the edge of the lead from splitting, as it is subjected to a continual strain, and the most skilful men cannot always avoid it. But if a split does occur, it should be cut out at once with a sharp knife, and the edge left clean and as even as possible.

The art of bossing-up a break consists, not so much in hammering lead indiscriminately, as in working the metal in waves, produced bossing-stick and mallets, from one definite place to the other. mastering the art of bossing a break of this kind, the plumber

good idea of the malleability and ductility and general character of the metal, and how it is possible to stretch it in one direction and thicken it in another without disturbing its tenacity or reducing its durability.

Breaks round Trap-doors.—The ordinary kind of break is a puzzle to many, but it is a greater puzzle to find the lead to stand up round a trap-door or circular sky-light in a flat roof. A trap-door, for instance, such as that shown in fig. 114, measures outside the curb 2 ft. by 1 ft. 6 in., and the lead is to stand up 6 in. on each of the four sides. If it were possible to use every particle of lead in the rectangle, which contains just 3 sq. ft., it would not be sufficient for the turn-up, which requires $3\frac{1}{2}$ sq. ft. But as it is hardly practicable to boss the whole of the rectangular area into the sides, considerably more than the area of $\frac{1}{2}$ ft. is necessary to make up the deficiency.

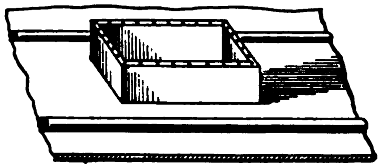


Fig. 114.—Breaks around a Trap-door

The way in which this amount of lead is obtained is typical of several other instances where, for the purpose of doing the work in one piece, it is necessary to draw a reserve of material from other parts of the sheet. This operation is shown by the sketches in fig. 115. In the first place, the piece of lead should be large enough to give the required area. That is to say, if the bay or gutter needs to be only 3 ft. wide just at this spot, the lead should be cut, say, 6 in. wider, and also longer, the extra size being more or less according to the amount of extra lead required for the stand-up around the sky-light or trap-door.

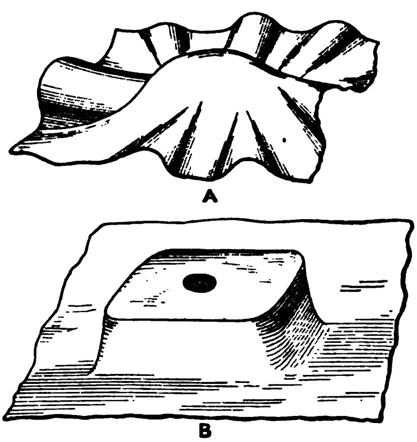


Fig. 115.—Method of "Gathering" Lead for Bossing-up a Curb

The sketch at A (fig. 115) shows the lead buckled up roughly in the form of an umbrella. A large mallet is now used to work on the ridges, and drive the lead towards the centre, and at the same time to flatten out the outer surface. This has to be repeated three or four times until a good lump is gathered towards the middle of the piece, like that shown at B. When a sufficient reserve is gathered, and this, of course, must be judged by the plumber himself, a clean round hole about 4 in. in diameter is cut out of the centre of the lump, and the edge is worked outwards to the size required. Considerable care is necessary to prevent the lead splitting, especially when the stand-up is approaching the upright angles, but if the lead is bossed regularly and the edge driven-in continually, there is no reason why the thickness when finished should be greater than the actual substance of the lead. It must be admitted that this kind of bossing is often left very thin, as there are many otherwise skilful plumbers who do not seem able to master the art of bossing-up breaks.

Another way to obtain the same result is shown in fig. 116. Instead of working-up a lump, the lead is bent in the form shown, and this may represent nearly the height and width of the trap-door curb. The lead is then firmly secured to a bench or the floor by nails at the edges, or, better still, by some pieces of timber screwed down on the outside edges. In this way two sides of the rectangle are formed, and all that is necessary now is to boss down the two ends in the manner shown. These are bossed down like two extensive roll ends, and the danger in this case is, not the stretching and splitting of the lead, but the bossing of the lead too thick. In order to avoid this, the surplus from the bossing-down of the ends must be continually drawn outwards by means of the bossing-stick or mallet, while a large mallet or a flat dummy is held on the under side to prevent the lead from "gathering", instead of stretching outwards as it should do. Although this method may be used in some cases with advantage, it is not always advisable, as a curb can often be worked with less labour, as will be shown in the setting-out of a lead flat in the next chapter.

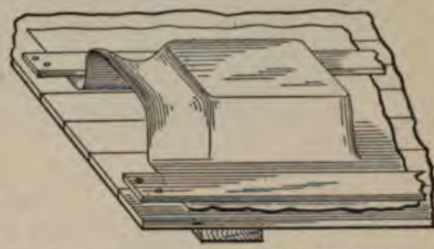


Fig. 116.—Alternative Method of Working a Curb

CHAPTER III

LEAD FLATS

Lead-covered flats have to be arranged in various ways, but there are a few well-defined principles which may be applied to nearly all those which can be correctly termed flats. There are many lead-covered roofs, such as the main roofs of churches, which are constructed at such an angle as to make the word "flat" inapplicable, and these will be described separately.

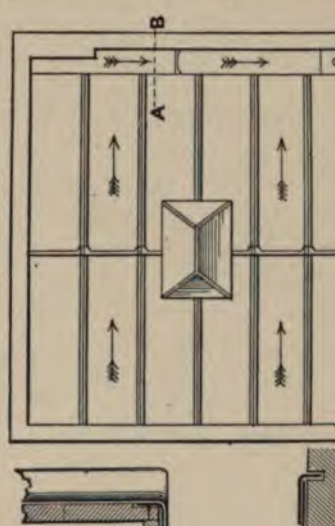


Fig. 117.—Plan of Lead Flat and Section of Gutter

We will suppose an ordinary form of flat roof like that shown in fig. 117, which has a parapet on the sides and ends, and a parapet-gutter on one side. There is one break formed by a chimney, and four around a trap-door.

The Gutter.—So far as the gutter is c[illegible] already made in connection with a parapet-gutter [illegible] every part. The only difference is that the lead [illegible] er

the slates, is turned over on the edge of the flat into a sinking in the woodwork and nailed, as shown in the section at A B.

The fall of the flat to the gutter should also be the same as that allowed for gutters, and certainly should not be more than 2 in. in 10 ft. The length of the bays should not be more than 10 ft., and the width should, except under special circumstances, be governed by the width of the sheet of milled lead, due allowance being made for the girth and covering of the roll. The size of the roll ordinarily is about 2 in. in diameter, and, for the same reason as that which fixes the height of a drip, they should not be less on flat roofs.

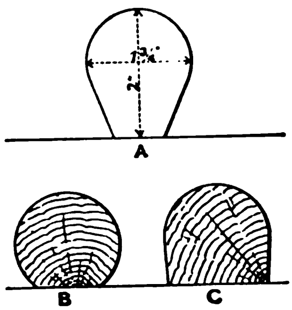


Fig. 118.—Sections of Wood Rolls

The roll may be a little less in width, but the important feature is that it should be undercut at the sides, as shown at A, fig. 118, and not like B or C. The object of this is to form a key for the lead to fit into, in order to hold it down in its place without depending on nails driven through the undercloak into the roll. Although nailing is done to a certain extent, it is not with the idea of holding the lead down in its place; this is better done by the shape of the roll. The roll, then, should be 2 in. high, 1¾ in. wide in its widest part, and not more than 1 in. wide at the base.

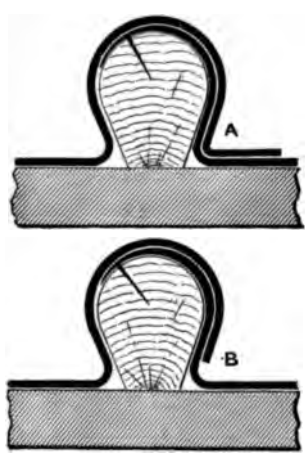


Fig. 119.—Two Methods of Trimming the Overcloak

The covering on the roll is the next debatable question. The writer's opinion is that the covering shown at A, fig. 119, is the best in every way. The idea of cutting the overcloak short, as in B, in order to prevent capillary attraction, is a mistaken one; because, if the roll is not high enough to prevent the water rising between the laps by capillary action, the cutting of the overcloak short in this way will not get over the difficulty. On the contrary, the water is likely to get inside by being blown up by the wind and assisted by capillary attraction—especially as the edge of the overcloak is sure to lift and become loose. But when it is trimmed off on the flat, as shown at A, the lower margin stiffens the edge and tends to keep the overcloak in its place. This is all the more important where lead flats are situated in exposed places, for cases have been known where the overcloak has become loose, and the wind has got under it and ripped the bays off. As the lead is not held by tacks or nails, the cloaking of the roll should be made as secure as possible.

Positions of the Rolls.—Having determined the size of the rolls, the positions of the rolls can now be set out. The usual plan is to fix the width of the bays by the width of a strip of lead formed by cutting

a 7-ft. sheet down the centre. The undercloak of the roll requires 3 in., and the overcloak 7 in. A little less than this will do, but if the lead is to be trimmed, without being cut short in various places, these dimensions should be allowed for the roll covering. The remaining width, namely, 2 ft. 8 in., should be the space between the rolls, or 2 ft. 9 in. between the centres. If these widths do not quite work out in the whole length of the flat, it is usual to make the last bay either a little wider or narrower as may be required. To regulate the width of each bay so that they may all be equal would often involve a large amount of waste by the margins, which would have to be cut off each one. In the case of church or other roofs, where the rolls and the width of the bays are regarded as a feature in the design, it is, of course, necessary to cut the lead to suit, and in these cases the bays are generally much less in width than those on ordinary flats.

The drip running along the centre of the flat should be similar to the drips already described, but it is advisable to make it a little deeper than the rolls, as shown at A, fig. 120, where the finish of the laps is also shown.

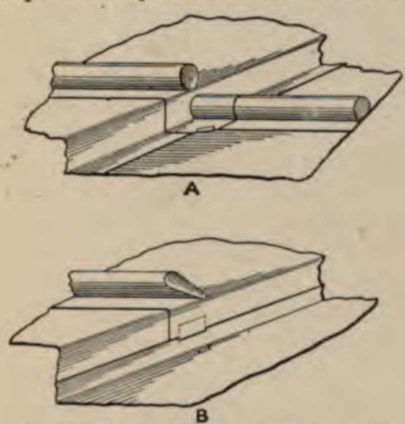


Fig. 120.—Ends of Rolls at Drips and Gutters

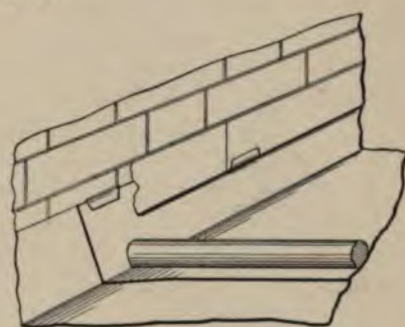


Fig. 121.—Flashing and End of Roll at Wall

The roll ends, both at the drip and at the edge of the gutter, should be cut off square, with the edges slightly rounded, although in some cases they are finished like that shown at the edge of the gutter, B (fig. 120). So far as their efficiency is concerned, the shape matters very little. The latter is supposed to economize labour, but this is rather doubtful.

Where the lead stands against the wall, the height should be 6 in., and the undercloak should form a tack to clip over the overcloak in the manner shown in fig. 121; this holds the two laps close and prevents them from becoming loose. In this sketch a section of the straight flashing is shown, and the former description of flashing applies to it.

Ridge Roll.—The flat above referred to falls in one direction only, but it may also be laid to fall from the centre to the two sides, in which case the drip will not be required, but in its place a central or ridge roll must be fixed, into which the other rolls will intersect. The bos ar-
cloak over these intersections is generally regarded by
what difficult piece of work. A common fault is th

scanty on the bay which corresponds to that numbered 4 in fig. 122. This bay should always have an extra width on the overcloak side at the top corner. If this is not allowed in the cutting-out, the corner should be carefully stretched out by means of a large mallet. It must be admitted that stretching lead is not usually advisable, but it had better be a little thinner at the intersection than too short; otherwise it cannot be finished satisfactorily. Fig. 122 indicates the order in which the bays are laid, and also the manner in which the lead should be trimmed off.

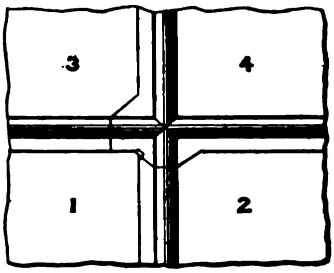


Fig. 122.—Intersection of Rolls

Seam-rolls are formed wholly of the sheet-lead, as shown by the sections in fig. 123. This is a very ancient method of forming seams to bays on flat roofs, and the principal object is to obtain a more secure fixing than that provided by wooden cores. It is questionable whether seam-rolls are necessary on ordinary flats where no extra security is required; in fact, there is much to be said in favour of the wooden lead-covered roll, on the ground of its more substantial character, especially where there is much foot-traffic over the roof. Certainly seam-rolls are found on flats that have been in existence for a great many years, albeit in many cases they have been trodden flat, and otherwise have become shapeless. But in

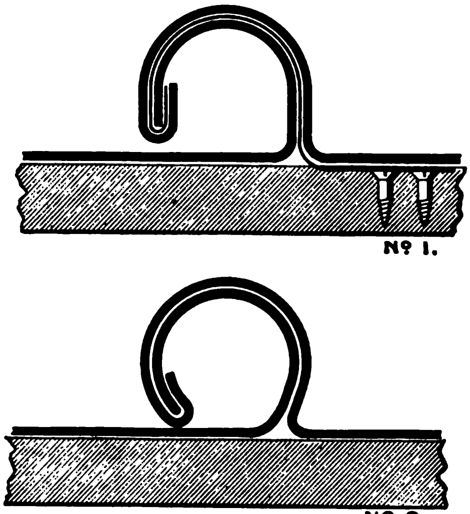


Fig. 123.—Seam-rolls

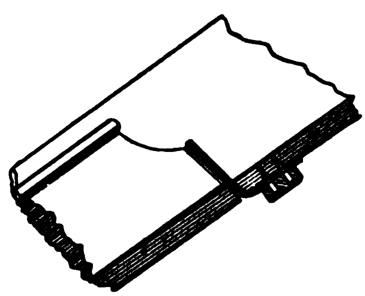


Fig. 124.—Lead Lug on Undercloak of Sloping Roof

the case of flats with a considerable fall, and in exposed positions, such as on towers and turrets, the seam-roll is undoubtedly the most suitable form, although other means also have to be employed in such cases to hold the lead in its place. In the first place, the bays should be much smaller than those on ordinary flats, and each bay needs a special arrangement for fixing. One of the best plans is to leave a tongue or lug on the upper end long enough to turn through a slot cut in the roof-boarding, and securely screwed or nailed on the inside, as shown by the section in fig. 124. When the space underneath the roof-boarding is not accessible, the bays have

to be held in their place by means of two or more rows of copper nails and also by secret tacks, as described below.

In addition to the secret tacks, the lead is further secured by sheet-copper tacks folded in the seam-roll in the manner shown in fig. 123, No. 1. These should be about 3 in. wide, and long enough to clip over the edge of the undercloak, and they also should be screwed to the roof-boarding about 3 or 4 in. from the centre of the roll, in order to give room for a certain amount of movement; for if the fixing is immediately under the roll, the upward strain caused by expansion will soon draw the screws.

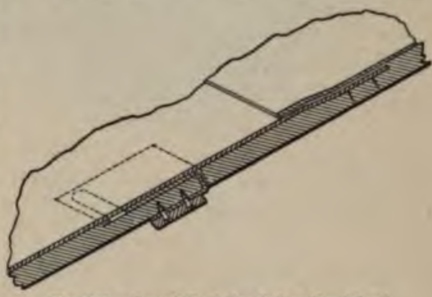


Fig. 125.—Secret Tack for fixing Sheet-lead

Secret Tacks and Soldered Dots.—The secret tack is a sheet-lead or copper tack, the lower end of which is soldered (or, as it is usually termed, "sweated") to the under side of the bay, and the upper end is nailed or screwed to the roof-boarding, as shown in fig. 125. The tack should be about 8 in. long and 6 in. wide, and the fixing to the roof should be as far from the soldering as practicable.

This plan appears to be contrary to the rule that lead on roofs should not be fixed by soldering, and in the case of soldered dots, which are so frequently made use of in instances of this kind, the objection is quite justified. But if the secret tack is arranged properly, the fixing is sufficiently removed from the soldering to allow for a large amount of movement which may be caused by expansion and contraction of the lead; consequently the strain on the soldering is reduced to a minimum. In the case of soldered dots (fig. 126), however, the fixing is absolutely rigid, and the strain, which in exposed places is almost irresistible, is directly on the fixing which the dot affords, the result being that either the screw or nail in the dot is drawn out of the timber, or the lead cracks close to the edge of the solder. There are instances where the dot may be usefully employed, but not when only one or two clout nails are driven through the lead before the dot is soldered. T dot secure—after the lead has been bossed into the ready for soldering,—a stout brass or copper screw washer under the head, should be carefully screwe somewhat loose; then the soldering should be thoroughly to "tin" to the washer and to the wipe the solder flush with the face of the l

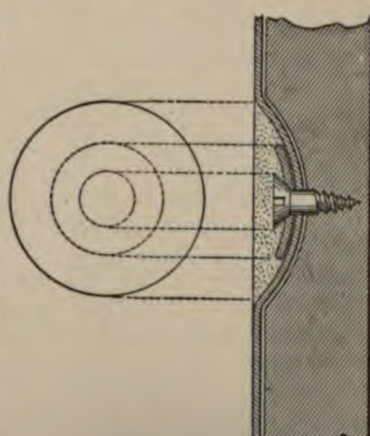


Fig. 126.—Soldered Dot

CHAPTER IV

STEP-FLASHINGS, SOAKERS, AND VALLEY-GUTTERS

Among the several means used for forming a weathering between the side of a sloping tiled or slated roof and a brick wall, step-flashing is undoubtedly the most reliable. On small property it is generally regarded as expensive, and recourse is had to cement fillets, and sometimes zinc soakers are buried in the cement fillet. The latter addition is certainly an improvement, but the builder has often cause to regret that he did not use step-flashing in the first instance, for the cement fillets crack, and the zinc soakers beneath often increase the tendency to crack.

Methods of Arranging Step-flashing.—There are three principal methods of arranging step-flashing, but the style most in favour is what is known as "step-and-cover flashing" (fig. 127), and under ordinary conditions it answers the purpose very well. Another style is called the combined step and secret gutter (fig. 129), but from any point of view very little can be said in favour of it, except that it can be finished before the slating is done, so that there is no need to climb over the roofs after the slates are laid. The very best plan under all circumstances is undoubtedly the hanging step-flashing with soakers (fig. 130).

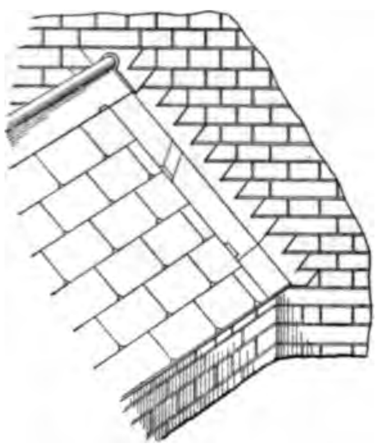


Fig. 127.—Step-and-Cover Flashing

Step-and-Cover Flashing.—The objection that is sometimes raised against the first method is that the cover flashing on the slates is likely to be blown up by the wind in exposed places, as indeed it is; but this is often the result of improper fixing. The ordinary size of the lead for this form of flashing is 1 ft. wide, 6 in. being on the slates and 6 in. up the wall. After the lead is cut up in 7-ft. lengths, this being the width of the sheet, it is set up along the centre to a right angle, and a line is struck 2 in. from and parallel to the centre-line to determine the inside ends of the steps. It is then placed in position and the line of each step marked to the joints in the brickwork. When this is done the lead is put on the bench and the triangular pieces cut out, a 1-in. margin being left to turn into the joint. These margins are turned over by means of a step-turner, which is made of wood or of thick sheet-iron.

Before the flashing is put in its place, bale tacks should be securely fixed for clipping over the edge of the lead on the slates. These tacks are usually about 9 in. long and 2 in. to 3 in. wide, and are fixed to the roof-boardin[illegible] or slating-battens with clout nails. They should not lie on the sl[illegible] right angles to the wall, but should slant downwards as shown by th[illegible] lines in fig. 127. The object of this is to prevent the rain from

along the top edge of the tack to the wall. There should be at least one tack in the centre of each 7-ft. length of flashing, and in exposed places

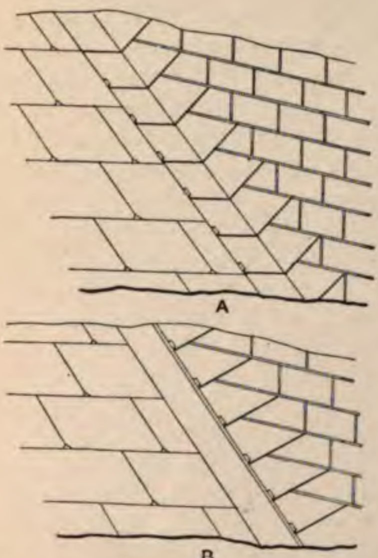


Fig. 128.—Varieties of Step-and-Cover Flashing

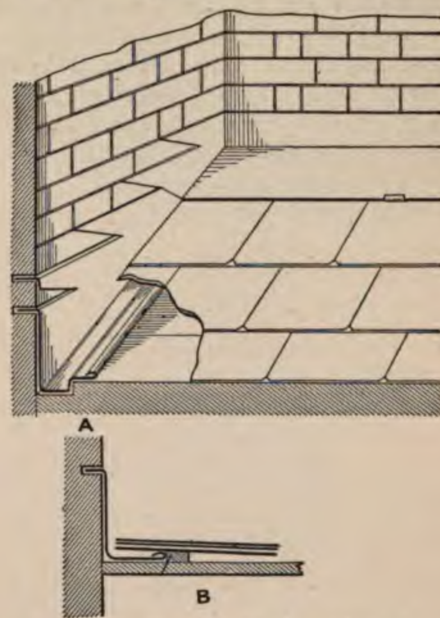


Fig. 129.—Step-flashing and Secret Gutter

two or more should be used. There is no need of a bale tack at the laps—which should not be less than 4 in.,—as these are made to tack themselves by a lug, which is left on when the edge is trimmed off.

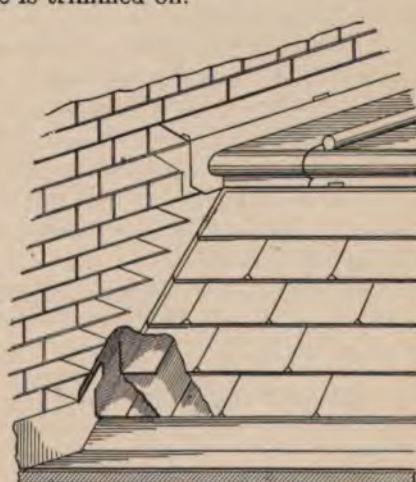


Fig. 130.—Hanging Step-flashing with Soakers

Fig. 127 also shows the top ridge roll and straight flashing, and the method of finishing around the end of the roll or around any other form of ridge stopping against the brickwork. As to the wedging of the steps into the brickwork, the remarks which were made with reference to straight flashing apply in this and all cases of flashing to brickwork.

In the north of England it is usual to arrange the step-and-cover flashing as shown at A, fig. 128. The cover on the slates has therefore a lap to each step, but sometimes the cover is fixed in long lengths, the edge turned up against the wall, and the steps made in separate pieces and fixed as shown at B. The idea is that the ordinary form of step-flashing, like that shown in fig. 127, is not sufficiently water-tight at the inside angles of the steps,

and it is therefore necessary to form a distinct lap at this point, which is obtained by using a separate piece of lead for each step.

In the **step-flashing and secret-gutter** method (fig. 129) a sinking for a narrow gutter is formed in the roof-boarding parallel to the wall. This is generally 3 in. wide and from 1 in. to 2 in. deep. Sometimes it is formed merely by nailing a piece of springing or tilting on the boarding as shown at B, fig. 129, but this is not at all satisfactory. The better way is shown at A. The disadvantage of this system is that the gutter is easily filled up with twigs and leaves, and the water then overflows the gutter and gets into the roof. It should, therefore, only be used in very short lengths, if at all.

The **hanging step-flashing with soakers** (fig. 130) is suitable in all circumstances. There is, indeed, no better method of making a water-tight joint between a slate or tile roof and a wall, while there are many cases where the step-and-cover flashing would be useless, and the secret gutter unreliable, such, for instance, as in the case of a roof like fig. 131, where one part of the side wall is set to an angle. Here the rain running down the roof would pass under a lead cover, and a secret gutter would not be large enough to take the rush of water at this point, but soakers would be perfectly safe.

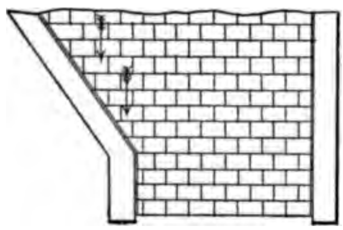


Fig. 131.—Plan of Roof and Flashing

Soakers.—A soaker is best described as a metal slate turned up against the wall. The size of the soaker should be determined by the size of the slates or tiles. A soaker must be laid on each course of slates. It should be turned up against the wall 3 in., and lie on the slate just half the width of the slate, or the same width that one slate overlaps another horizontally. Sometimes soakers are cut to a less width, and do not, therefore, have the same weathering as the slates. This is a mistake. The proper length of a soaker is found by adding the depth of the course (or exposed part of each slate) to the depth of the lap or weathering, *plus* an inch for fixing by nailing over the top edge of the lower slate. The width is found by adding half the width of the slate to the stand-up against the wall. If the size of soakers for a 20-in.-by-10-in. slate is required, it will be seen that if the courses are 8½ in. and the lap 3 in., then 8½ in. + 3 in. + 1 in. = 12½ in. = length, and 5 in. + 3 in. = 8 in. = width. Calculated in this way, the following table can be used for reference:—

Size of Slates.	Size of Soakers for 2½-in. Lap.	Size of Soakers for 3-in. Lap.	Size of Soakers for 3½-in. Lap.
24 in. × 14 in.	14¼ in. × 10 in.	14½ in. × 10 in.	14¾ in. × 10 in.
24 ,, × 12 ,,	14¼ ,, × 9 ,,	14½ ,, × 9 ,,	14¾ ,, × 9 ,,
22 ,, × 12 ,,	13¼ ,, × 9 ,,	13½ ,, × 9 ,,	13¾ ,, × 9 ,,
20 ,, × 10 ,,	12¼ ,, × 8 ,,	12½ ,, × 8 ,,	12¾ ,, × 8 ,,
18 ,, × 10 ,,	11¼ ,, × 8 ,,	11½ ,, × 8 ,,	11¾ ,, × 8 ,,
16 ,, × 10 ,,	10¼ ,, × 8 ,,	10½ ,, × 8 ,,	10¾ ,, × 8 ,,
14 ,, × 8 ,,	9¼ ,, × 7 ,,	9½ ,, × 7 ,,	9¾ ,, × 7 ,,
12 ,, × 8 ,,	8¼ ,, × 7 ,,	8½ ,, × 7 ,,	8¾ ,, × 7 ,,

An ordinary roofing tile measures 10½ in. by 6 in., and the sizes of soakers will therefore be 7½ in. by 6 in. for 2½-in. lap (4-in. gauge), 7¾ in. by 6 in. for 3-in. lap (3¾-in. gauge), and 8 in. by 6 in. for 3½-in. lap (3½-in. gauge).

Sheet-copper is very often used for soakers, and with considerable advantage, because they can be much thinner than lead, and this allows the slates to lie closer one upon the other. In any case there is no need to use lead of more than 4 lb. to the square foot, which is just over $\frac{1}{16}$ in. thick; but if copper is used, a fourth of this thickness is ample, or about 26 B.W.G. Zinc is used for soakers to a very large extent, but it is doubtful whether it is advisable to use it in conjunction with lead step-flashing, owing to the galvanic action set up between the two metals, which has the effect of causing erosion. If zinc soakers are used, the step-flashing should also be of zinc, and this when carefully prepared and fixed is fairly durable.

When the slating is commenced, the first row of slates is called the under-eaves, and upon this should be laid the first soaker. The next row of slates is properly known as the first course, and upon this is placed the next soaker. The first soaker is therefore covered by the first course of slates, and the next soaker is covered by the second course, and so on as shown in fig. 130. The upper end of the soaker is generally fixed by two nails driven through the top edge into the roof-boards.

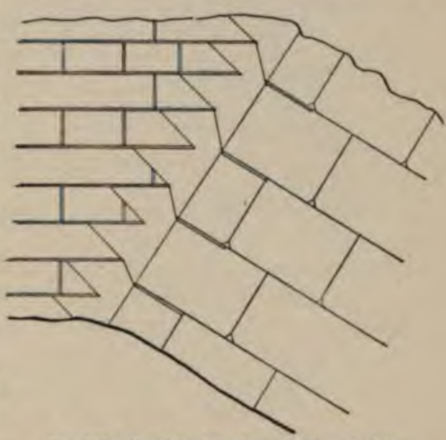


Fig. 132.—Combined Soaker and Step-flashing

In some parts of the country it is the custom to make the soaker and one or two steps of the flashing in one piece (fig. 132). This method is useful when there are some small pieces of lead to make use of; but the disadvantage is that a plumber must be in attendance to fix each piece as the slater proceeds with his work. This is not necessary when ordinary soakers are used, because the slater can fix the soakers if they are prepared for him, and the plumber can fix the step-flashing after the slater has finished. Besides, it is unnecessary to have the soaker of the same thickness as the flashing, which should not be less than 5-lb. lead.

A common fault to be found in step-flashing is that the stand-up against the wall is not high enough, and the steps have been made to slant the wrong way, with the result that the rain-water running down the wall easily finds its way behind [illegible] under the roof.

Soakers for Hips.—Besides [illegible] of soakers there are others which are used on mitred hip[illegible] soakers of any kind are used, the slates or [illegible] bedded in cement or black putty, b[illegible]. Lead or copper soakers make th[illegible] hip-soakers are

made with the edges parallel to the hip, as at A, fig. 133, but more commonly they are cut to taper as shown at B. One soaker is provided for each course of slates, like the soakers already described. The shape of the soaker is found by getting the angle formed by the bottom edge of the slates and the hip line, and the size is found in the same manner as that adopted for the wall soakers. It is important that hip-soakers should be as thin as possible, and although nothing thicker than 4-lb. lead should be used, 3-lb. is quite substantial enough; but thin sheet-copper is more suitable, because if the hip slates do not lie very close they are likely to be blown off by the wind.

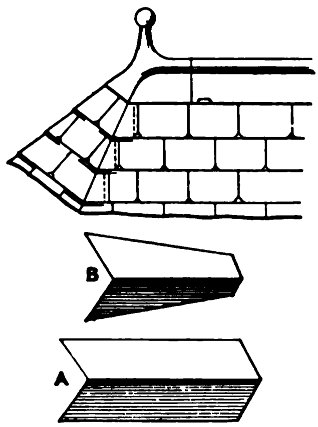


Fig. 133.—Single-course Hip-soakers

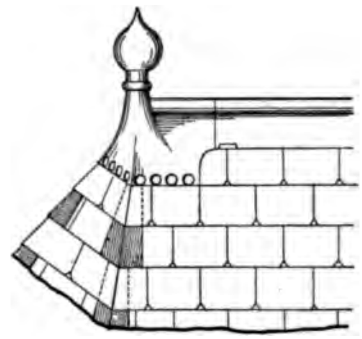


Fig. 134.—Double-course Hip-soakers

Another kind of soaker (fig. 134) is made to cover the mitre of each alternate course. In this case the soakers are of the same length as the slates, one half being covered and the other half exposed. This style is sometimes regarded as an ornamental feature on the hips of towers, but the principal advantage is that it makes the hip slates much more secure where they are exposed to high winds.

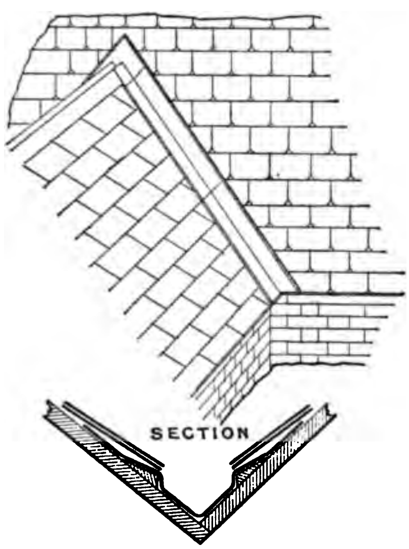


Fig. 135.—Valley-gutter in Slated Roof

Soakers for Valleys.—Soakers are frequently used in valleys on tiled roofs, and are much more suitable for the purpose than the ordinary form of valley-gutter (fig. 135) which is constructed on slated roofs. The valley-soaker may be similar in shape to the hip-soaker shown at B, fig. 133, the only difference being that its position is reversed. The advantage claimed for the ordinary valley-gutter is that a narrow passage is left for a man to get about the roof without having to walk on the slates; but on tiled roofs this is very seldom provided for, as the appearance of the gutter is objectionable.

An ordinary **valley-gutter** (fig. 135) is generally from 4 in. to 6 in. from the angle to the springing, and 6 in. should lie under the slates on each side, and in length the pieces should not exceed 7 ft.

CHAPTER V

HIPS, RIDGING, AND CURBS

At one time it appeared that lead coverings to hips and ridging were to be superseded by earthenware coverings, but during recent years lead has again come more into favour. The old-fashioned methods of arranging and fixing the sheet-lead had very little to recommend them, especially when the only fixing consisted of several lead-headed nails driven through the lead into the wood rolls. By the modern methods this form of fixing is quite unnecessary.

Size and Shape of Roll.—It is important that the roll should be of a suitable shape (fig. 136), and stand well up off the slates, so that the lead can be dressed into the throats of the roll in order to form a key. The size of the roll, providing it is not less than $1\frac{1}{2}$ in. in diameter, is of little importance. The usual size is the same as the rolls used for flats (figs. 118 and 119), but they are sometimes made much larger, in order to give a bolder appearance. The base of the ordinary roll should not be more than about 1 in., and should be set on a blocking-piece, as shown in fig. 136, unless the ridge-piece is kept up and chamfered off to suit. It is a good plan to place wooden fillets on each side of the blocking-piece, for the top edges of the slates to abut against. The lead can then be dressed well into the throat without breaking or disturbing the top course of slates. It also has the effect of enabling the lead to lie close, and to remain undisturbed after it is once fixed and the bale tacks (A A, fig. 136) turned.

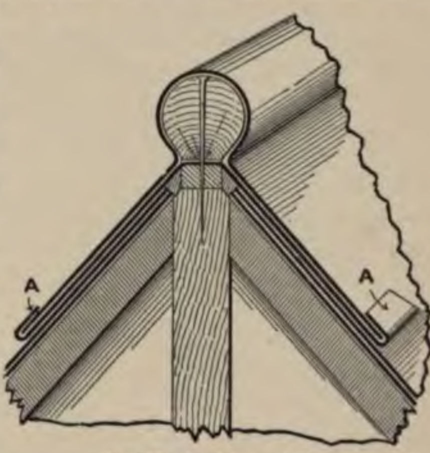


Fig. 136.—Lead-covered Ridge

Fixings.—These tacks should be about $2\frac{1}{2}$ in. wide, and long enough to pass under the roll and form a tack on each [illegible]dge, and must, of course, be put in their place before the w[illegible] or, if not, slots must be cut and the tacks slipped thro[illegible] through the roll and the tack at the same time. T[illegible]ne bale tack in the centre of each 7-ft. length, bu[illegible]ld be used.

Seven feet is a convenient len[illegible]ow

for a lap of 6 in. on the slates on each side, and, as an ordinary roll has a girth of about 5 in., the total width of the lead is 1 ft. 5 in. It is best, however, to cut the lead an inch wider, in order to leave enough on the edges, when they are trimmed off, for forming a tack at each lap, as shown at A, fig. 137.

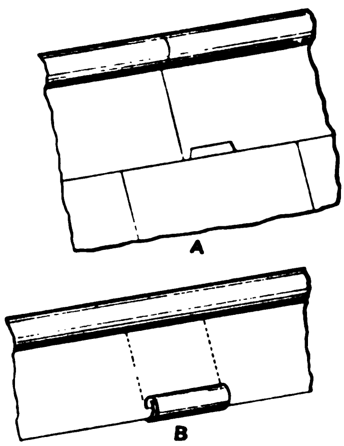


Fig. 137.—Lap and Bale Tack in Ridging

Other more secure fixings are sometimes necessary, in order to resist the force of the wind. Iron or copper bands, made to the shape of the roll and covering, are in some cases screwed on to the roll. In others the roll-piece is welted to the leaves which cover the slates, and the undercloak of the welt is nailed to the roll. But one of the simplest and most effective methods is to use strong wide bale tacks, with the ends welted to the edge of the leaves, as shown at B, fig. 137. If this is carefully done, it is almost an impossibility for the wind to blow the lead off.

Intersection of Rolls on Hips and Ridge.—Fig. 138 shows a plan of the intersection of the hips and ridge-roll, and the way to trim and tack the laps. In ordinary cases the tops of the hip-rolls are fixed by being nailed securely into a sinking cut into the roll, and generally this is sufficiently substantial if the lengths are not more than 7 ft., but the shorter they are the better. In the case of large and nearly upright rolls on the hips of spires, special methods of fixing are required, because the mere nailing of the top edge would be of little use. Such rolls should be

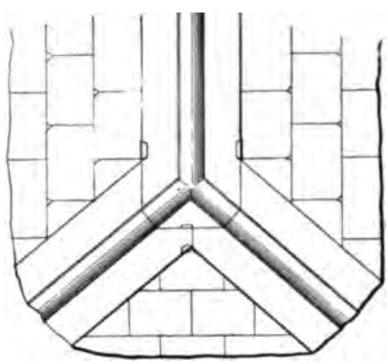


Fig. 138.—Intersection of Rolls on Hips and Ridge

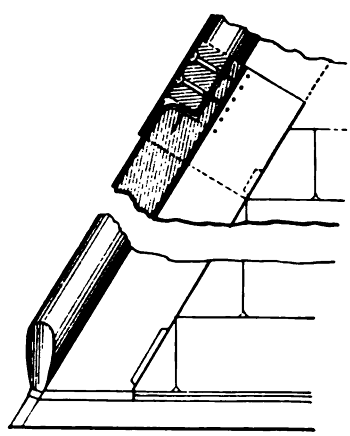


Fig. 139.—Method of fixing Lead on Hip-roll of Spire

covered with shorter pieces, and mainly held up by the top ends being bossed into a recess cut in the roll, as shown in fig. 139. After the lead is bossed over, the piece of roll cut out is replaced and screwed. In addition to this, the bale tacks should be about 6 in. wide, and welted to the edge of the leaf which lies on the slates, or turned through a slot in it.

Curb-rolls and Aprons.—One of the simplest methods of finishing the curb on a mansard or other roof is by means of an ordinary apron (fig. 140). In such a case the lead should lie under the slates 6 in., and over the curb 8 in., if it is finished with a straight edge as at A; but if the apron is shaped to some ornamental design (B), there should be a full 6 in. of weathering over the slates above the highest point of the cut pattern.

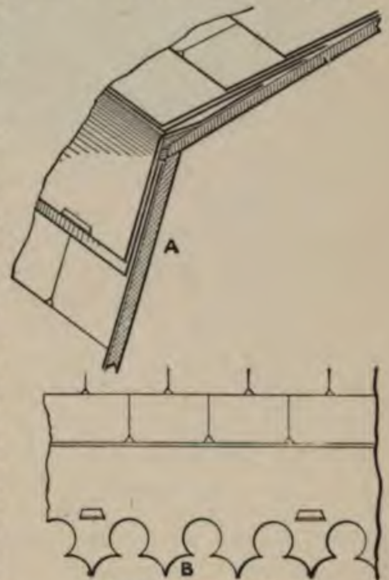


Fig. 140.—Apron for Curb

There should always be a fairly thick springing on the edge of the curb, as this is more important on curbs than it is in gutters. If a proper springing, or "tilting fillet" as it is sometimes called, is not used, the lower edges of the slates will not lie close down, and the wind will get underneath and blow them off. As already mentioned, the first row of slates, or under-eaves, is about half the depth of the full slate, and would, of course, lie flat in its place. But when the first full course was put on, the upper end being nailed to the roof-boarding, the centre would lie on the top edge of the under-eaves, and the lower edge, as shown at A, fig. 141, would be raised considerably above the bottom edge of the under-eaves. The same defect would occur in the next course of slates; in fact, every course would be in an unsatisfactory condition. But when a thick springing-piece is fitted as shown at B, the top and bottom edges of the slates lie close, and are in a better state to resist the action of the wind.

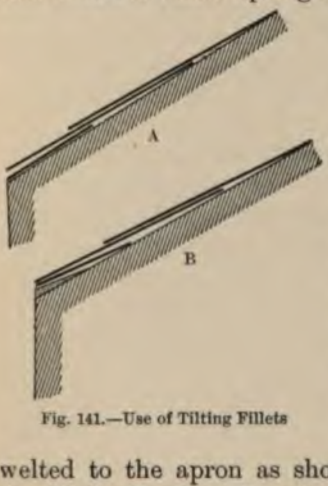


Fig. 141.—Use of Tilting Fillets

A more substantial way of fixing the apron is shown in fig. 142, where the apron and the underlap are separate. The apron is put on first, and securely nailed close up to the edge of the curb. The underlap is then put in its place, and welted to the apron as shown. In order to do this substantially a fillet should be fixed to the edge of the curb, against which the edges of the lower slates can abut; to this also the apron is nailed, and it forms a solid backing for the flat welt. In too many cases this fillet is omitted; the slates are therefore taken to the angle of the curb, and the apron

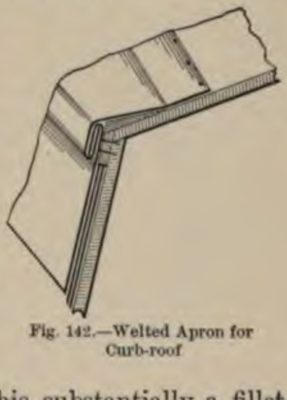


Fig. 142.—Welted Apron for Curb-roof

rests upon them and causes the slates to become loose and the bottom edges to tilt.

On prominent curb-roofs a torus roll is often used, and sometimes mouldings are formed beneath; but if the lead is not properly treated it will become loose and baggy, and the mouldings will be obliterated. The fault is in most cases caused by the lead being put on in one piece instead of two or three, according to the shape of the moulding.

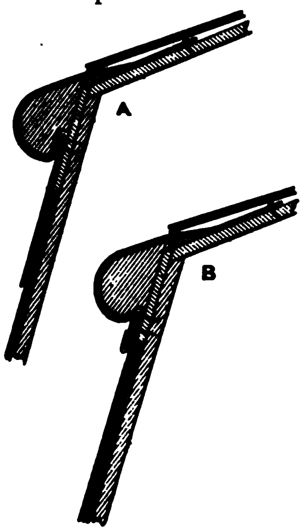


Fig. 143.—Curb-rolls and Aprons

If the roll is of an ordinary form, like fig. 143, the apron should always be in a separate piece; but this can be arranged in two ways. In that shown at A, the roll-cover and the apron are nailed on the curb before the roll is in its place, and, after the roll is fixed, the lead is folded upwards and nailed at the top edge on the roof-boards. In the case of B, the roll must be well undercut for the purpose of providing a key for the lead, which is nailed at the top first and folded downwards, and then up into the undercut of the roll, the apron, of course, being nailed on first. The lower edge of the roll-covering is held up in the undercut by sheet-copper tacks, as shown in the section. These should be about 2 ft. apart, and folded up tight. If this precaution is not taken, the edge will drop and the roll will become loose and baggy. Of the two methods, that shown at A is by far the more substantial.

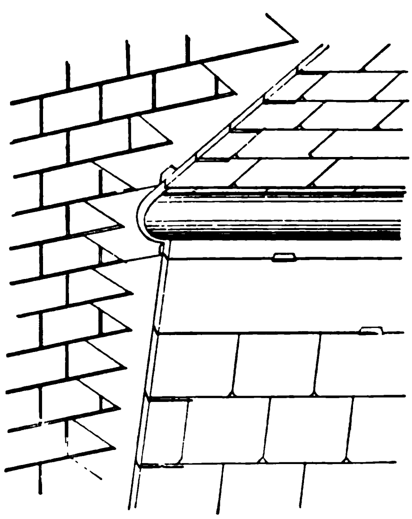


Fig. 144.- End of Curb-roll against Wall

Curb-roll against Wall.—Where the end of a curb-roll stops against a wall (fig. 144), the lead covering should never be stepped into the brickwork, but should turn up against the wall about 3 in. This may appear to be rather difficult in the case of A, fig. 143, but it need not be at all troublesome if the work is done in the proper way. Before the piece which covers the roll is nailed on the curb, the width of 3 in., which is to turn up against the wall, should be folded over flat on the piece, and so folded round the roll. The edge is then gradually lifted and worked up to the wall. In doing this the tendency is to make the edge thin, but by driving the lead inwards the thickness to a large extent can be maintained; and even if the top edge is somewhat thin, it is of no importance, as the flashing, as shown in the sketch, covers it to within $\frac{1}{2}$ in. of the roll. Another way to work the stand-up is to turn up the margin on the

piece, and corrugate the edge as shown in fig. 145. This is done with two mallets, one on each side, and the blows should be directed downwards, in order to avoid stretching the lead too much. When the lead is folded round the roll, it will require very little bossing to get it into its place.

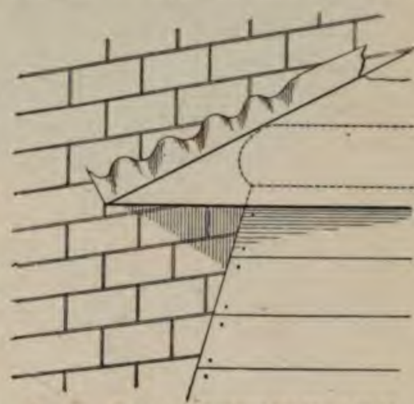


Fig. 145.—Method of Working the Stand-up at End of Curb-roll

A similar process is required if the roll is covered as at B, fig. 143; for, if the margin for the stand-up were only folded over, on attempting to work it back to the wall the lead would draw out of the undercut of the roll, and it would be very difficult to get it back again. There is therefore considerable advantage in bossing the stand-up as much as possible to the right shape before it is put in its place.

The step-flashing, as seen in the sketch, is made specially to fit to the roll, and trimmed off about ½ in. from the angle, the lower corner of the step-flashing being tacked by a lug from the lower flashing.

The sketch shows soakers and hanging step-flashing, but if the ordinary step-and-cover flashing is used, the method of finishing the curb-roll is not affected. The only difference is that the small piece of step-flashing over the end of the roll is as shown, while the flashing above and below has the 6-in. margin attached to it for covering the edge of the slates. The style shown, however, with soakers, is the best plan to adopt.

CHAPTER VI

DORMER-WINDOWS, TRAP-DOORS, AND SKYLIGHTS

Dormer-windows are very often a source of weakness in slated and tiled roofs, but there need not be any difficulty in making them water-tight, if the preliminaries are arranged satisfactorily, and the lead fixed in a proper manner.

We will take as an example a dormer-window (fig. 146) which is partly an internal and partly an external dormer, and the methods for arranging the lead covering may be applied to either one or the other of these kinds of dormers.

The First Piece.—From the section (B) it will be seen that the small flat below the window is the first piece of lead to be laid. It should stand up at the sides 6 in., and the bottom of the window-sill should not be less than this height. In this respect many internal dormers are at fault, for when the sill is too low a driving rain in the direction of the window will find its way in where no one would have expected. This is, however,

to a very large extent prevented by the apron being fixed before the sill is in its place, and then turned up on the inside of the sill about an inch, and copper-nailed. In many cases the apron is only nailed under the sill on the outside, but is then very rarely water-tight.

The cheeks above the lower flat are next in order, and the difficulty about

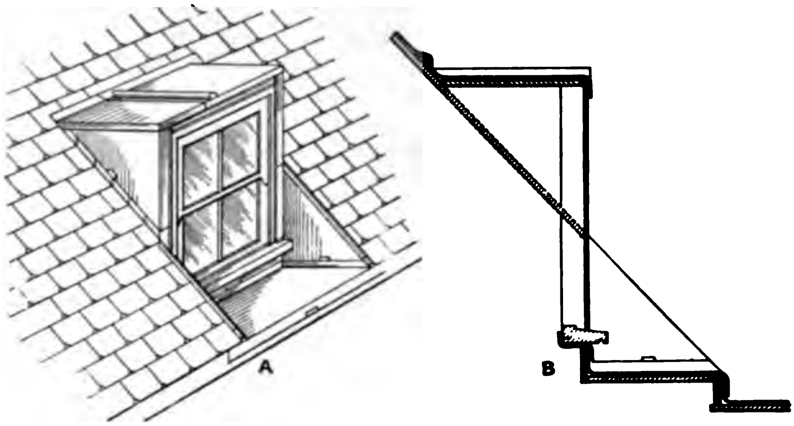


Fig. 146.—Dormer-window

these is where they finish at the top edge against the slates. The best way of treating this edge is shown in section in fig. 147. A wooden roll should be fixed on the edge, to stand about 2 in. above the line of the slates. A soaker should be laid to each slate, and the stand-up copper-nailed to a sinking on the side of the roll. The lead forming the cheek is now turned over the roll, and fixed by sheet-copper tacks clipped into a welt on the edge, which turns over in a line with the slates, as shown in the section. The upright edge of the cheek should turn on the window-frame about 2 in., and be close copper-nailed, and a flat welt be turned over the nails to protect them from the weather. It may be well here to explain that, while the nailing of lead exposed to the weather cannot be recommended under all circumstances, it makes all the difference in the world when the heads of the nails are protected by a welt of the lead being turned over them. The reason is that the rain cannot then soak in behind the nail-heads and cause the wood to rot, and thus allow the nails to become loose and fall out, as they will do if the heads are not covered.

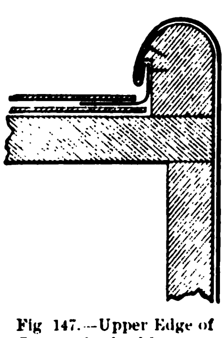


Fig. 147.—Upper Edge of Lower Cheek of Dormer

Upper Part.—The next part of the work is the covering of the cheeks on the upper part of the dormer. As soakers are advised for the tops of the lower cheeks, soakers should also be used for the upper cheeks, with the difference, of course, that they are at the bottom instead of the top. The lower soaker on the upper cheek will lap the upper soaker on the lower cheek, and the lead covering of the cheek should be trimmed off about 1 in. from the angle, as shown in the view of the dormer (fig. 146, A).

The front edge can be turned round on the window-frame, and copper-nailed as before described. The top edge of the cheek should be turned over on the dormer-top about 2 in., and copper-nailed.

The top of the dormer is now covered, and when it is not more than about 4 ft. square it may be done in one piece. But if larger than this it is advisable to arrange for a roll in the centre, from back to front, as shown. The lead should be worked over a springing 4 in. up the roof, and lie 6 in. under the slates. There are various ways of finishing the front and side edges. The simplest is to work the lead down over the angle (fig. 146, A), and trim it off about 3 in. from the angle in a straight line. The main point about this, however, is the way the edge is tacked. It will be readily seen that an ordinary bale tack, merely clipping the edge, would be useless for the purpose of keeping the lead covering down in its place; for, as soon as expansion and contraction commence, the lead will lift out of the tack, and probably be blown off. It is necessary, therefore, to fix the lead, not by a soldered dot, but by what is known as an under-tack or a welted tack, either of which will hold the lead in its place without binding it too tightly, as a dot would. The section of the under-tack is shown at A, fig. 148. It consists of a sheet-lead or copper tack nailed or screwed to the top edge of the dormer; and a lug, which is left on the cover-piece when the edge is trimmed, is folded under it as shown. The welted tack is not so neat, but it is effectual. A bale tack, either of lead or copper, is fixed in the usual way, and this is folded into the lug in the form of a flat welt, as shown at B.

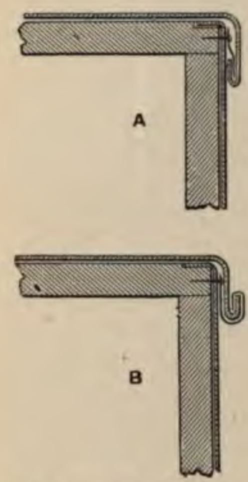


Fig. 148.—Tacks at Edge of Dormer Top

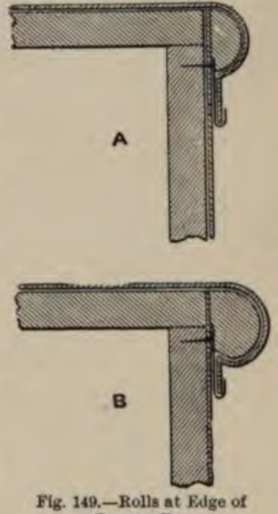


Fig. 149.—Rolls at Edge of Dormer Top

Finishing.—In many cases the edge is finished with a roll similar to that shown at A, fig. 149; but a roll of this shape does not hold the lead on firmly, especially if the tacks at the bottom edge are of the ordinary kind. The welted tack described above is better, although this does not keep the lead tight on the roll. The only satisfactory way is to use a roll with an undercut as shown at B; then, if the lead is worked up into the undercut, ordinary sheet-copper tacks only are needed to keep the lead in its place.

Trap-doors and Skylights.—Like dormer-windows, trap-doors and skylights in a slated or tiled roof are very often a source of trouble, but there is no reason why they should not be as weathertight as any other part of the roof, providing that the wood-work and lead flashings are arranged in a proper way. A common fault is the improper arrangement of the curb; this should stand up from the line of the slates at least 6 in.,

and the upper side should be vertical, as shown in the section at A, fig. 150, and not, as is often the case, at right-angles to the roof-slope. When it is formed in the latter way, the water running down the roof during heavy rains may flow over the top of the curb (particularly if the roof has a sharp pitch), and get through under the trap-door or skylight as the case may be.

Methods of arranging the Lead.—As in the case of ordinary flashing, the lead can be arranged in three ways—either cover-flashing, as shown at B, fig. 150, or secret gutters, or soakers and hanging flashing, as in fig. 152. In any case, the apron is fixed first, and when cover-flashings are used, these can be done either before or after the slates are on, although it is necessary, of course, to fix the gutter at the top before the slating reaches that point. The most convenient way, however, is to get the whole of the flashing on before the slating is started. This also avoids the breaking of the slates, or the more brittle tiles, while bossing the corners into their place. In order to do the bossing conveniently, 9-in. boards should be fixed at the bottom and sides to represent the thickness of the slates or tiles. When the lead-work is in its place, but not trimmed off (as this is best left until it is quite finished), the flashings are turned up against the sides while the slating or tiling is being done, after which they are dressed down and trimmed off and the tacks turned.

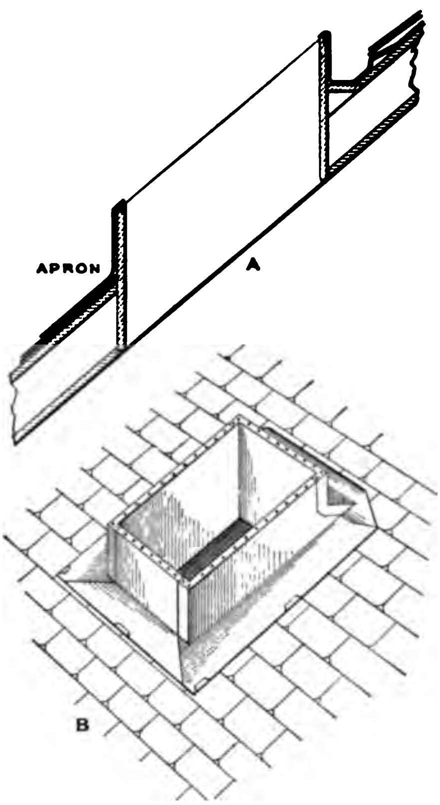


Fig. 150.--Skylight in Sloping Roof

The apron should lie 6 in. on the slates, and turn over on the top of the curb, where the edge should be secured by copper nails. The sides should be of similar width, and the lower ends bossed round the corners on the front of the apron about 2 in., and trimmed and tacked as shown. A still more secure method is to form a flat welt on the edge with the ends of the apron and side flashings as shown at A, fig. 151.

The gutter should be 1 lb. per foot heavier than the sides and apron, the usual weights being 5 lb. for the sides and apron and 6 lb. for the gutter. The lead should lie 6 in. under the slates, and turn over on the top edge of the curb. Where it is difficult to get the back of the curb to a sufficient height, an improvement is effected by forming a flat welt by means of another strip of lead copper-nailed to the curb, as shown

at B. This forms an effectual check to the rush of water down the roof above the skylight.

Hinges.—In the case of a trap-door hinged at the top of the curb, this welt would in some instances prevent the door being opened wide enough for anyone to get through the opening. But if the door were hinged at the side, as it should be in all cases, there would be no difficulty.

Condensation-channel.—It is necessary in the case of skylights to provide some means for catching any condensed water that may flow down the glass to the bottom of the light. This is usually done as shown in the sectional part of fig. 152, a moulding or fillet being fixed to form a condensation gutter, from which grooves

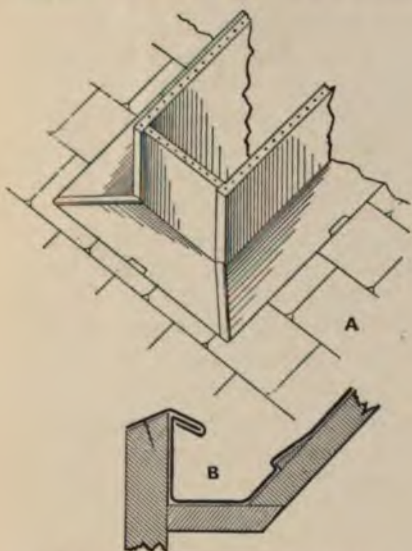


Fig. 151.—Welted Flashings to Skylight

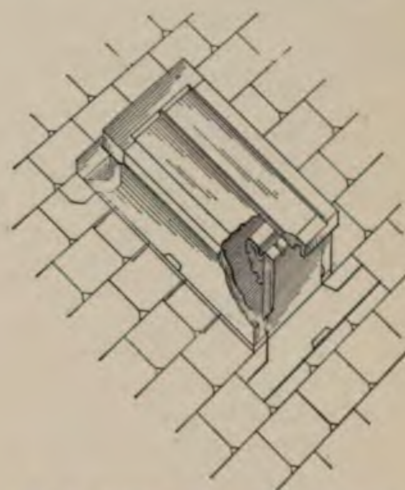


Fig. 152.—Skylight with Soakers and Flashing and Condensation-channel

are formed over the edge of the curb to the apron. The lead to line this gutter is sometimes a part of the apron; in other cases it is in a separate piece and is made to lap over the front of the apron.

Apron along Top-rail.—Another important feature is the apron shown in fig. 152 along the top-rail of the light. This is not often adopted, but if a thoroughly sound job is required, this apron should cover the top-rail, lap over the glass, and hang about 1 in. below the under side of the frame, and form a dripping edge over the top gutter.

It may be well to mention here that, in all cases where cover-flashing is fixed, and particularly in skylights or other projections from a roof where a large quantity of rain-water is likely to flow down by the side of and on to the flashing, a small tilting fillet should be fixed against the wall or curb, in order to tilt the slates outwards, and thus prevent the water from gathering under the cover-flashing, and finding its way between the edges of the slates and the wall or curb. Where soakers are used, however, this is quite unnecessary, as the form of the soaker, as already explained, renders such leakage impossible.

Lead-work on Roof (Plate VIII).—The plan and detailed sections shown in Plate VIII are an example of plain lead-work on a flat, and the various applications of sheet-lead to a tiled roof.

The flat is divided into bays 2 ft. 8 in. wide between the rolls, and these are covered in the manner described at p. 122.

Instead of the flat finishing at the lower edge with a torus roll in the usual way, gutters are formed on each side, and the water from these discharge through outlets at the sides and at the two ends to the tiled roof, the outer sides of the gutters being capped by ridge-tiles of the same material as the tiles on the roof. The gutters and flat have a fall of 1½ in. in 10 ft., the section of the drips being similar to those shown in A, fig. 101, p. 114. The outlets are in the form of shallow cesspools carried under the ridge-tiles, and the ends bossed down on an apron which lies on the tiles.

The vertical side shown in the section B–B is covered with lead, the seams are welted, and these are held in their place by sheet-copper tacks folded in the welts, and fastened to the wall by wooden dove-tailed blocks being pinned into the brickwork and the tacks screwed to them.

Additional fixing is provided to the vertical bays by turning over the top edge 2 in. on the woodwork of the flat, and securing it by close copper-nailing.

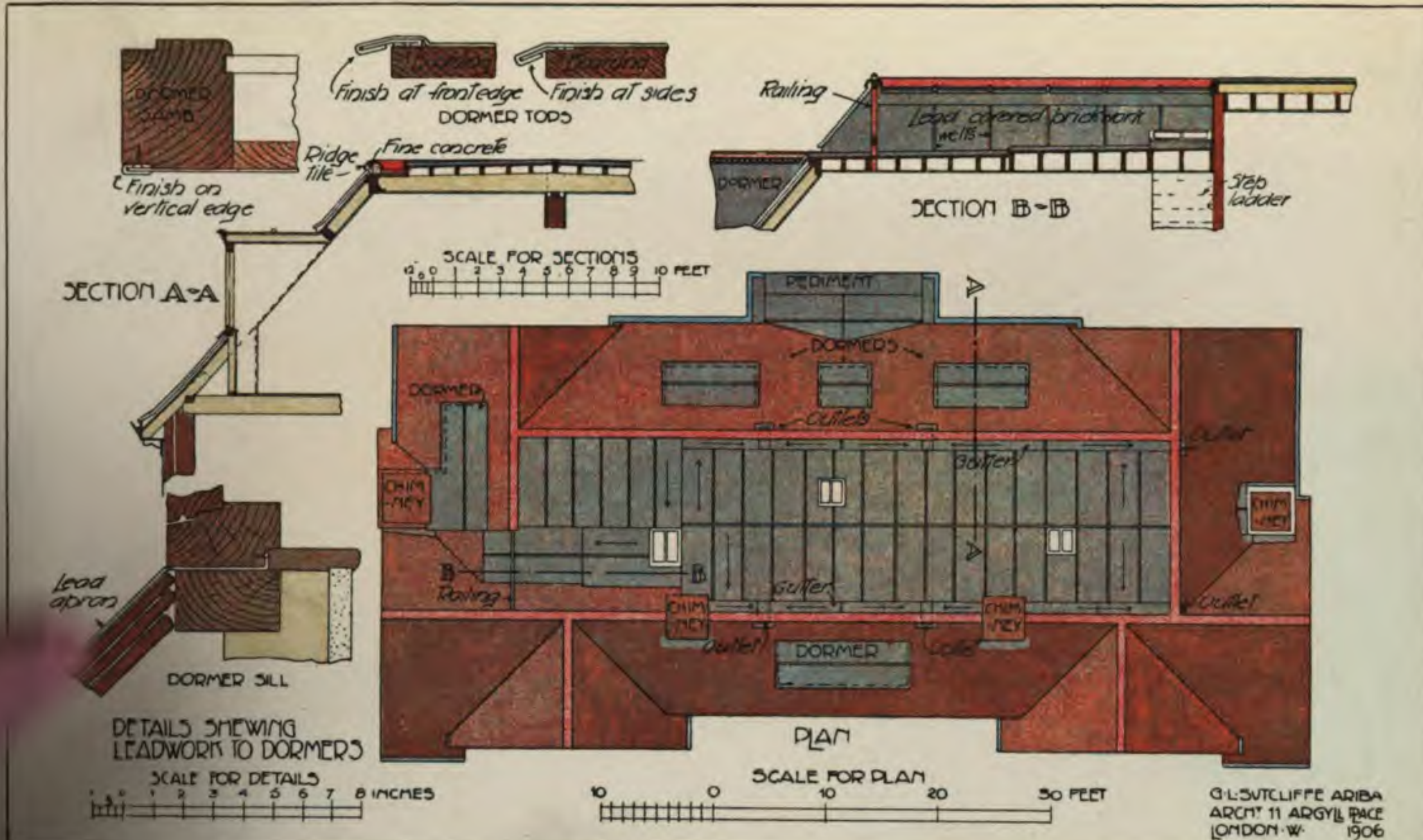
The aprons of the dormers are taken under the sills, and turned up inside in order to prevent the rain driving in, and the sides of the dormers are weathered by soakers which stand up under the cheeks 4 in. As the cheeks are not large no dots or secret tacks are required, sufficient fixing being provided by the turn-over and nailing on the top edge, the flat welt and nailing on the front of the dormer-jamb, and one or two bale tacks on the lower edges.

The covers to the dormers have rolls arranged parallel to the roof with the overcloak outwards, in order to prevent a torrent of rainwater running over the front of the dormer-window. The front edge is also raised by means of a welted fixing with the same object in view. The whole of the water is therefore carried down each side, where the edges are secured by a welted edge turned over a fixing strip, as shown in the sections.

CHAPTER VII

TOWERS AND DOMES

The covering of domes and towers with lead is a part of plumbers' work which generally occurs at long intervals, and therefore most men are unable to obtain a very wide experience of this class of work. As a rule, however, when a plumber is well versed in the art of bossing and thoroughly acquainted with the characteristics of the metal, work of an unusual form does not present to him any great difficulty.



ROOF-PLAN AND DETAILS SHOWING LEAD FLAT, DORMERS, &c.

Herring-bone Arrangement of Rolls.—The octagonal spire shown in fig. 153 has the rolls arranged in what is generally known as "herring-bone" fashion. The principal advantage of this arrangement is that the lead can be fixed in comparatively small pieces, and therefore the fixing can be made more secure than when much larger pieces are used. One most important thing is that the wooden rolls should be well undercut, so as to afford a good key for the lead to be worked into, as shown in the section at A B. Then if the rolls are of sound, well-seasoned timber, and securely screwed on to the boarding, and, where possible, into the framing timbers underneath, and if the lead is carefully bossed over the intersections and the undercloaks well fixed with copper nails, there need be no fear of the lead moving to any appreciable extent. The laps of the overcloaks may, of course, open a little, but if both ends are well bossed into the keys or undercut of the cross rolls, and a sheet-copper tack sweated on the undercloak against the roll, as shown in the section, the lead cannot move far out of its place.

If the bays are more than about 2 ft. 6 in. square, it may be necessary to provide additional fixing by secret tacks in the middle of each bay. These tacks, as already described, can be sweated on the back and securely fixed into a sinking in the boarding with copper screws, the fixing, of course, being done while the upper part of the bay is turned back in a similar manner to that described for a church roof.

Seam-rolls.—There can be no doubt that the most substantial way to hold the lead on a tower of this kind is by forming seam-rolls, but the cost is usually prohibitive, as the time required to form the whole of the rolls without a wooden core, and to do the difficult bossing at the intersections, would be twice as much as that needed for covering

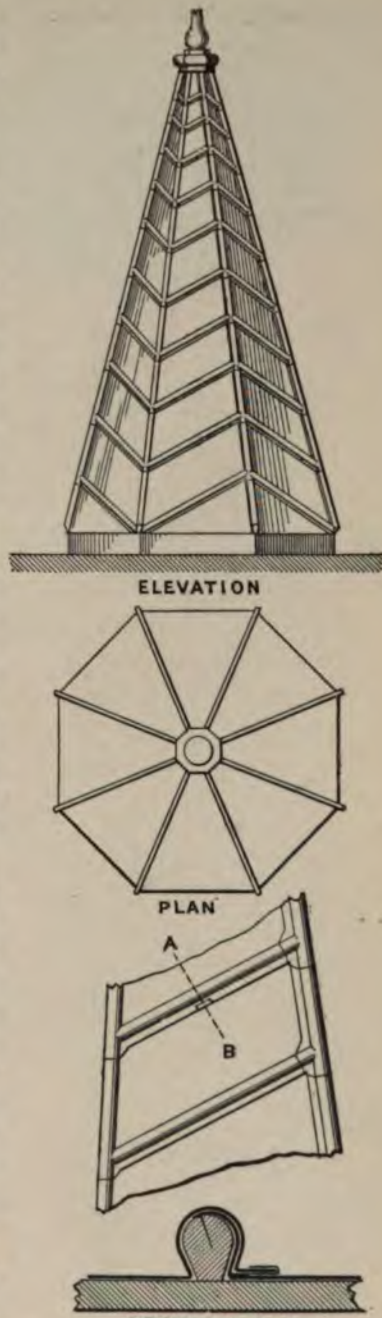


Fig. 153.—Octagonal Spire with Herring-bone Rolls

wooden rolls. The sketches in fig. 154 show, at A, how the wooden rolls are finished, and, at B, how the seam-roll work is arranged.

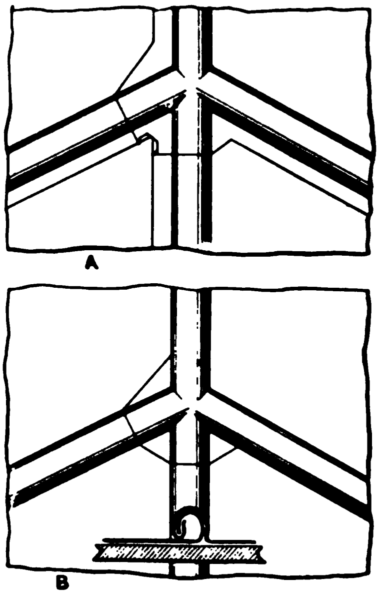


Fig. 154.—Intersections of Rolls
A, Wooden Rolls; B, Seam-rolls.

It is difficult, if not impossible, to describe clearly on paper the method of arranging the seam-rolls at the intersections, but it may be pointed out that on a nearly vertical face, like that of a tower, there is no need to be very particular about the undercloaks, so that these, after allowing for a little weathering above the flat surface, are to a great extent mitred together, and the bay which forms the overcloak is made to cover the intersection as shown. It will be remembered that in forming seam-rolls, sheet-copper tacks are screwed to the wood-work and folded inside the roll over the undercloak, and this, in such a case as that under consideration, forms a most secure and substantial fixing, more especially if the copper tack can be turned through a slot in the boarding and screwed inside.

Wood Angle-rolls and Intermediate Seam-rolls.—Where the rolls on the angles of the tower are larger than the cross rolls, a much simpler plan can be carried out. The bays with seam-rolls between the wood angle-rolls can be fixed quite independent of the angle-rolls, thus avoiding intersections of the kind which are so difficult to manage in the other case, and the angle-rolls can be covered with separate pieces of lead, the edges of which can be welted to the edges of the bays, which stand up against the angle-rolls. A section and view of this method are given in fig. 155. One vertical roll is shown covered, and the other angle shows the sides of the bays with the edges welted to receive the overcloak welt of the roll-covering. As a matter of fact, this style is much better than when the whole are seam-rolls, and can be done in about the same time as the wooden-roll style, besides being a better job in every way.

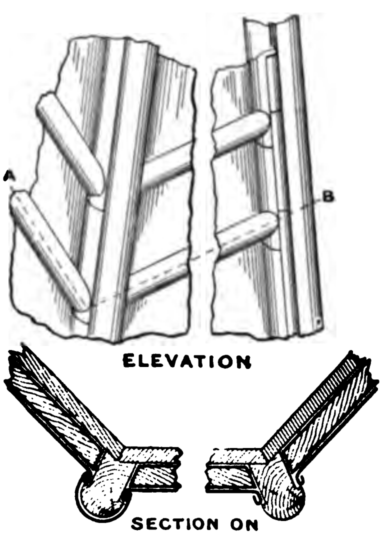


Fig 155.—Spire with Seam roll Bays and Wood-roll Angles

Apex of Slated Spire.—For the next example we will take a finial and top capping to a slated turret (fig. 156), the tower to be square in plan, and

the finial circular, the alteration from the square to the round being formed in the neck of the finial.

The first part of the work is the capping from the slates to the base of the finial, which is supposed to be about 4 ft. deep from the finial to the bottom of the scalloped edge. The lead should not be less than 6 lb. to the foot, and 7 lb. would not be too heavy. The pieces of lead should be as small as practicable, because, when large pieces are fixed in exposed positions like this, the expansion by heat causes them to bulge and look very unsightly. It would therefore be well to do each side in two pieces, as shown, with a 6-in. lap in the centre, the top edges of each piece being fixed by two or three rows of large copper nails, and, where it is possible, by turning a lug, left at the top end, through the roof boarding, and fixing it inside in the way already described. The angles should be joined by a flat welt about $1\frac{1}{2}$ in. wide, having three sheet-copper tacks folded inside.

Fig. 156.—Finial covered with Lead

The finial can be covered in one or two pieces. It is not wise to attempt to boss very large pieces. It, of course, shows a considerable amount of skill when a large finial is covered with one piece of lead without the aid of any seam or solder, but, from a utilitarian point of view, it involves a large amount of wasted labour. There is no reason why the finial shown in the sketch should not be covered with two pieces, and laps formed at the points marked A and B. But to do this to any advantage the finial should be made in two pieces, having a hole through the centre, and supported by an iron or steel bolt, which, indeed, should form the fixing in any case. The different pieces can then be placed in position after each one is covered, starting, of course, from the bottom.

The upper stem can be covered by a short piece of soil-pipe, which has been bossed out at one end large enough to slip over the head after the lower part is covered; it can then be dressed into the wooden core and trimmed off at the line A. The lower piece should be bossed out of a circular disc of lead of the weight required. It is important, however, that the lead should be cut to as nearly the required size as possible. The usual way is to make a very rough guess; but if the lead is too large it will give twice the amount of work that it should, and if it is too small it has either to be stretched out so thin as to risk a fracture, and, if this actually occurs, the lead has to be cut off and a fresh start made with another piece.

To find the Area.—It is somewhat difficult, perhaps, to obtain the exact area of an irregular figure such as this, but there is no difficulty in getting it approximately correct. The surfa[illegible] B may be

described as two frustums of cones and the outside surface of a cylindrical ring. The sides of the frustums are of course curved instead of straight lines, but this will not materially affect the result.

Supposing the frustums to be 12 in. diameter at the largest end, and 6 in. at the smallest, and 8 in. high on the slant side, if the sum of the circumferences of the two ends is multiplied by the slant height, half the product will be the superficial area of each frustum. It works out as follows: $12 \times 3{\cdot}1416 = 37{\cdot}6992$, and $6 \times 3{\cdot}1416 = 18{\cdot}8496$; then $37{\cdot}6992 + 18{\cdot}8496 = 56{\cdot}5488$; and $56{\cdot}5488 \times 8 \div 2 = 226{\cdot}1952$ sq. in. The total area of the two frustums is $2 \times 226{\cdot}1952 = 452{\cdot}3904$ sq. in. The outside surface of the ring can be obtained sufficiently accurately by multiplying the circumference of the ring on plan by the girth of the moulding, which in this example is a semicircle. Supposing the ring to be 18 in. across and 3 in. thick, we have $18 \times 3{\cdot}1416 = 56{\cdot}5488$, and $3 \times 3{\cdot}1416 \div 2 = 4{\cdot}7124$; then $56{\cdot}5488 \times 4{\cdot}7124 = 266{\cdot}48$ sq. in., the area of the cylindrical ring. Accordingly the whole area required $= 452{\cdot}39 + 266{\cdot}48 = 718{\cdot}87$ sq. in.

Now, to find the diameter of a circle containing this area, the square root of this sum should be found, and then multiplied by $1{\cdot}128$, because the side of a square $\times\ 1{\cdot}128 =$ the diameter of a circle equal in area to the square. Therefore, the $\sqrt{718{\cdot}87} = 26{\cdot}8$, and $26{\cdot}8 \times 1{\cdot}128 = 30{\cdot}23$, which is the diameter in inches of the piece of lead required, supposing it to be bossed fairly equal in thickness over the whole of the surface to be covered. It is, of course, not advisable to work with the material too finely cut, so that it may be well to increase the diameter by about 1 in., and this will be found sufficient to provide for contingencies.

There is another way by which the amount of surface may be calculated, and although it is not so nearly correct, it has the advantage of being less complicated. If the part of the finial we have been dealing with is regarded roughly as a sphere, all that is needed is to strike out a circle twice the diameter of the sphere, and that will be the exact area. The rule is, that the superficial area of a sphere is equal to the area of a circle the diameter of which is twice the diameter of the sphere. In the case in point it will be necessary to take the mean dimension between the horizontal and vertical diameters. The former has already been taken as 18 in. and the latter is 16 in., the mean being 17 in. The circle would therefore be 34 in., or nearly 4 in. more than that found by the other method. But it must be noted that in this area the top and bottom circles, representing the sections of the finial at these points, are included, and as these circles are not to be covered with lead, the extra inches in diameter obtained by this method of calculation are not required. Although this may be regarded as a rough way to calculate the area, it is nevertheless much better than a mere guess.

Bossing the Lead.—The next point is the bossing of the lead to the form required before it is placed in position. It should first be formed into a kind of saucer shape, as shown at A, fig. 157, by the aid of a fairly flat-faced mallet used on the inside, and a flat, or rather a slightly-rounded, box-wood dresser on the outside. It can then be placed on the top of

a mandrel, or a piece of deal quartering with a rounded top, and worked down to the shape shown at B, until it is of just the right size to slip over the large part of the finial. Care must now be taken to draw out the material, so as to retain an equal thickness throughout, and at the same time to avoid over-stretching it, or a split will be made before one is aware that the lead is so weakened. When it is placed in position, it is a simple matter to boss the lead back to the wooden core, but on no account should it be "crowded in" by attempting to force it, but it should be bossed downwards and inwards at the same time, using always a smooth-faced round box-wood dresser or the side of a box-wood mallet. See also Plate VII B.

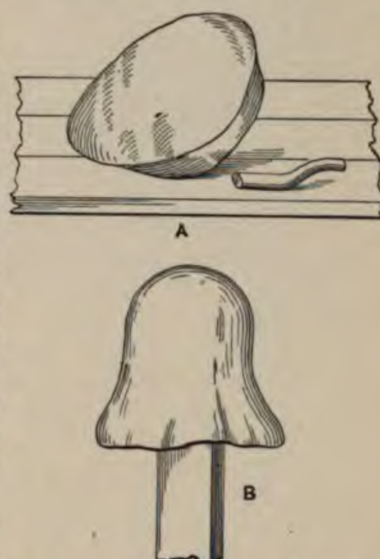


Fig. 157.—Method of Dressing Lead for Finial

The same remarks do not apply exactly to the bossing of the upper stem of the finial, as there is very little opportunity to draw the surplus lead out, except at the top point, where it can be easily bossed out by means of a mallet and a dummy inside, the hole being thus reduced to as small dimensions as these tools will allow. The finish of the point is done by bringing it to a pin-hole and then closing it over. Otherwise most of the surplus must be worked in, thereby causing the lead to become much thicker than that on the more prominent parts. This, however, does not matter, providing the lead is worked in without buckles.

No attempt should be made to clean off rough parts by means of rasps, files, or card-wire. The whole of the smoothing of the surface, so far as this may be necessary, should be done by the dressers or mallets, and the tool-marks left on the work.

The only part which requires more than usual care is an undercut similar to that on the head of the finial. If the lead at these points is driven straight in with drifts or chase-wedges it is very likely to make a fracture. It is necessary, therefore, to draw the lead away from the sides to the middle of the sinking, in order to ensure a sufficient thickness at these parts.

Ornamental turrets are sometimes constructed on the ridge of a roof, for the purpose of enclosing an air-extractor or some other form of ventilator. They are usually covered with lead or copper, and although we are especially concerned with lead coverings, it may be mentioned that the method hereafter described is suitable in the main for either of the metals. The principal difference is that the coverings on the mouldings cannot be bossed out of copper in the same way as lead can be treated, but have to be stamped or moulded in machines made for the pu

After the ridge has been covered with lead

the manner already described, an apron should be fixed all round the base of the turret (fig. 158), standing up 6 in. and lying 6 in. on the slates as shown. Supposing the turret to be octagonal in plan, the apron should be arranged in six lengths. Four of the lengths should slip up under the leaves of the ridge, as shown in the sketch, and the other two at the foot of the bays on each side are parallel to the ridge; the laps and tacks are indicated in the elevation.

The eight bays of the base can now be covered by a separate piece for each bay, providing that they are not too large. If they measure more than about 4 ft. by 3 ft., it is best to cover them by two or more pieces. Supposing, however, that in this case they do not exceed that size, they should be provided with one substantial secret tack of the kind already mentioned, which should be turned through a slot in the boarding, and securely fixed on the inside.

Fig. 158.--Ventilator covered with Lead

Each bay should be joined to the other at the angles by a flat welt (A, fig. 159), in which two or three sheet-copper tacks are folded and firmly screwed to the wood-work. These welts can be sunk into grooves in the boarding, so that they do not project beyond the face of the lead, or they can be made to form a seam standing out from the face. In some instances seam or other rolls are formed on the angles, as in B, but in that case the moulding at the top of the bays would have to be blocked out the thickness of the rolls.

The top edges of the bays should finish close up to the moulding, and be fixed by two rows of close copper-nailing.

The platform, which is level with the top of the moulding, should now be covered with four pieces, that is, one piece to each two bays of the octagon. This will involve the bossing of a break in each piece to fit the obtuse angle of the ventilator. The seams for joining the pieces may be flat welts, the outer ends of which should finish under the base of the columns. The outer edges of these pieces should be bossed over the moulding, and finish about 4 in. below, and the lower edge secured by sheet-copper tacks as shown at C, fig. 159. A still better plan would be to fix the mould-

ings after the lower bays are in their place. In that case the copper-nailing can be under the moulding, and then the lead covering can be trimmed off about 2 in. below, thus making a neater and better job. Four of the mitres on the moulding, by this plan, would be bossed over by a single thickness, and the other four would be covered by the laps where the platform-coverings join.

There is a point here which requires attention. Where the laps are formed on the moulding, there is a probability of the rain being driven by the wind along the members of the moulding far enough to reach the wood-work, and this, after a time, causes the wood to rot, if it does not do more serious damage. It is therefore advisable to form a vertical "water", or, as it is sometimes called "capillary", groove, in the wood-work, about ½ in.

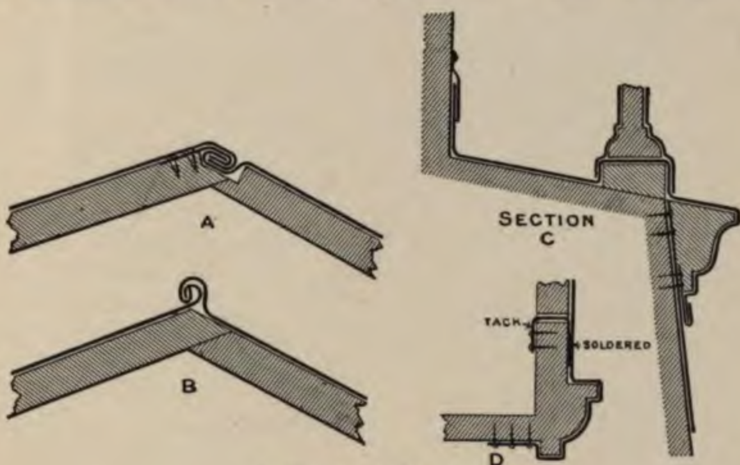


Fig. 159.—Details of Ventilator

wide and the same depth, and to work the undercloak into it. The overcloak, of course, covers the groove, and the water driven under the lap stops at the groove and flows down to the bottom of the moulding.

The stand-up against the ventilator requires a flashing, which may be either a copper or zinc flashing, soldered or riveted to the metal of which the ventilator is formed.

The columns should be covered out of their place, and fixed after the platform is finished. The method of covering them depends very much on their size. If they are not more than 4 in. in diameter, they can be covered by two or more pieces of drawn-lead soil-pipe, and the mouldings bossed in the same pieces. The ends should be also bossed over, especially the lower ends; then, if they are fixed as they should be, that is, by a steel bolt passing through the centre with nuts and washers on each end, and screwed on from the inside of the turret, the covered bases can be made water-tight to the platform by having a disc of imperishable material, such as asbestos cloth, placed between the base and the platform. There are several ways in which this can be arranged. One is to have circular blocks about 2 in. high fixed to the platform as bases for the columns. These are covered by

the pieces which cover the platform, as shown in C, fig. 159, but in that case the welts should be placed between the columns instead of beneath them, and the covering for the blocks should be bossed out of the middle of the pieces. The lead which covers the columns can then lap the block, and be trimmed off about ¼ in. from the flat surface, as shown. Although this is the better arrangement, it is not so neat as that in which the welts on the platform come on the angle.

Larger columns of this kind should be covered by the lead being folded round them, and a seam formed at the back, where it is not conspicuous. These seams can be safely made in the form of sunk flat welts, but in some cases they are soldered flush, and in others "burnt", or, as it should be more properly called, "fused", together by means of an oxy-hydrogen flame. This is far the best way of joining the seam, especially if it is sunk about ¼ in., and then cleaned off. The burnt seam is likely to be more durable if it is properly done, as lead is the only metal used, and consequently unequal expansion and contraction do not occur. The lead used for the covering should be as substantial as that described for the smaller columns.

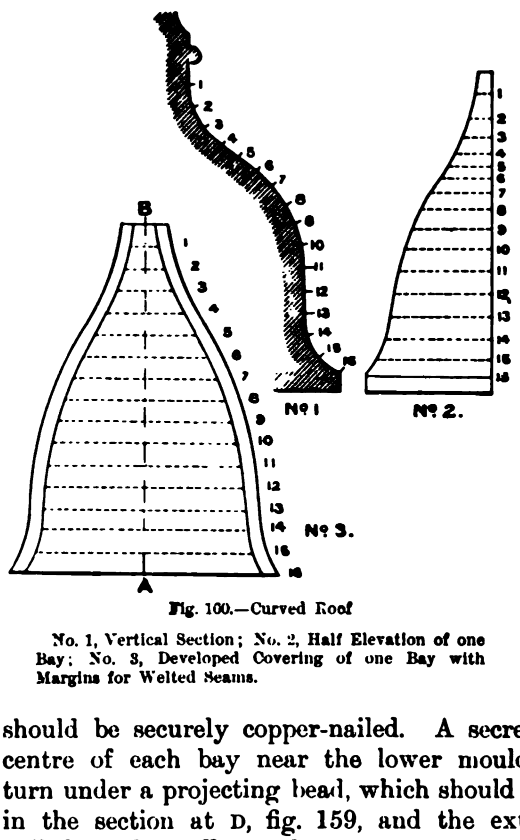


Fig. 160.—Curved Roof

No. 1, Vertical Section; No. 2, Half Elevation of one Bay; No. 3, Developed Covering of one Bay with Margins for Welted Seams.

The eight vertical bays can now be covered in separate pieces and joined with flat welts at the angles, and arranged to finish just below the top moulding, where they should be securely copper-nailed. A secret tack is also advisable in the centre of each bay near the lower moulding. The lower edges should turn under a projecting bead, which should form a dripping edge, as shown in the section at D, fig. 159, and the extreme edges should be copper-nailed to the soffit as shown.

The upper moulding should now be covered separately in four lengths, and joined by laps at four of the angles, the lower edges finishing about 3 in. below the moulding on the bays, and being provided with a sheet-copper tack in the centre of each bay, as shown in fig. 158. The upper edges should lie up the roof of the turret about 4 in., and be copper-nailed.

The roof should be covered with eight pieces, one to each bay, and the angles joined by flat welts either sunk or above the face. The pattern of the bays should be set out as follows. The full length of the curved surface

should first be measured by a tape, and a line of this length should be struck with a chalk-line on the piece of metal, or other material, that is to be used for a template, as shown at AB, fig. 160. Now divide both the bay and the line on the template into an equal number of parts by horizontal lines; the larger the number of parts, and the closer the lines, the more accurate will be the template. Then, by means of a rule or a pair of compasses, transfer the length of each horizontal line from the turret, or a scale drawing of it, to the lines on the template; when these are all marked, draw a curved line which shall pass through all the points marked on the horizontal lines, as shown in No. 3, fig. 160, and this will represent the actual size and shape of the bay. But before it is cut out, margins must be marked on each edge for the material required for the welts; if these are 1-in. welts, the margin on one edge will be 1 in., and on the other 2 in. Then the pattern can be cut. In some cases the template is made of zinc and sometimes of wood or lead.

Turning the Welts.—There is some difficulty in turning welts on curved angles of this kind, if the welt is turned after the bay is fixed, and it is not an easy matter to explain the process in writing. But there is a way of doing it by partly turning the welts while the lead is flat, and then, after carefully forming the curves to the shape of the roof, the welts can be hooked or slipped one into the other sideways, and then dressed tight. On small roofs of this kind there is very little need to fold sheet-copper tacks in the welts; if the welts are properly turned, no other fixing is required, because the curved form of the angle has the effect of keeping the welts tight. But on a straight angle, if the lead slips downward the welts are drawn open and the job is a failure. In such cases the sheet-copper tacks should be inserted, as they will prevent the lead from slipping, and thus avoid a strain on the welts.

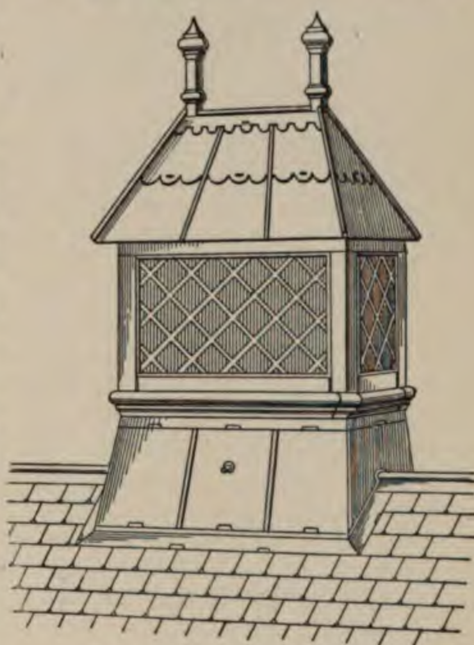


Fig. 161.—Large Ventilating Turret

The finial at the top can be covered by a piece of lead soil-pipe, bossed-in to the shape of the ball and mouldings, the lower edge being made to finish about 3 in. below the lower moulding.

Large Ventilating Turret.—In the case of a large ventilator in the form of a turret (fig. 161), there is a somewhat large flat surface on each side of the base, which should be divided up into small bays. When no particular design is required, this is best done as sl [illegible] ·parate

pieces of lead being joined by flat welts of the kind already described. The horizontal joints should be simple laps, and the centre of each bay should be held in its place by a sheet-copper tack as shown. It is important, also, that sheet-copper tacks should be folded in the welts and securely screwed to the wood-work. This is a case where one very often finds large pieces of lead used for covering the vertical sides, and held in place by soldered dots. But this kind of work is cheap and nasty, because, as already explained, the dots soon become useless and the lead hangs in bag-like bunches, and then tears away from its remaining fixing, which consists generally of a row of clout or copper nails at the top edge.

The roof should also be divided up into small bays, and joined either with welts or seam-rolls. The latter are more prominent, but the welts are very substantial and look well if the bays are properly arranged. Sometimes the lower edges of the bays are shaped to a particular pattern as shown. The square post at each end of the ridge can be covered by a piece folded round them, a flat welt being formed, either at one angle or in the centre of one side. The finials on each post can be covered by a circular piece of lead bossed over them, or by a piece of pipe bossed-in to the shape required.

The four posts which support the roof can be covered, the vertical edges being copper-nailed, and protected by a hardwood moulding, but in many cases these posts are constructed of oak or teak, and are not covered with lead. In that case the lead which covers the horizontal moulding should turn-in at the top edge of the lower rail, and, after being securely copper-nailed, should be covered by a hardwood moulding.

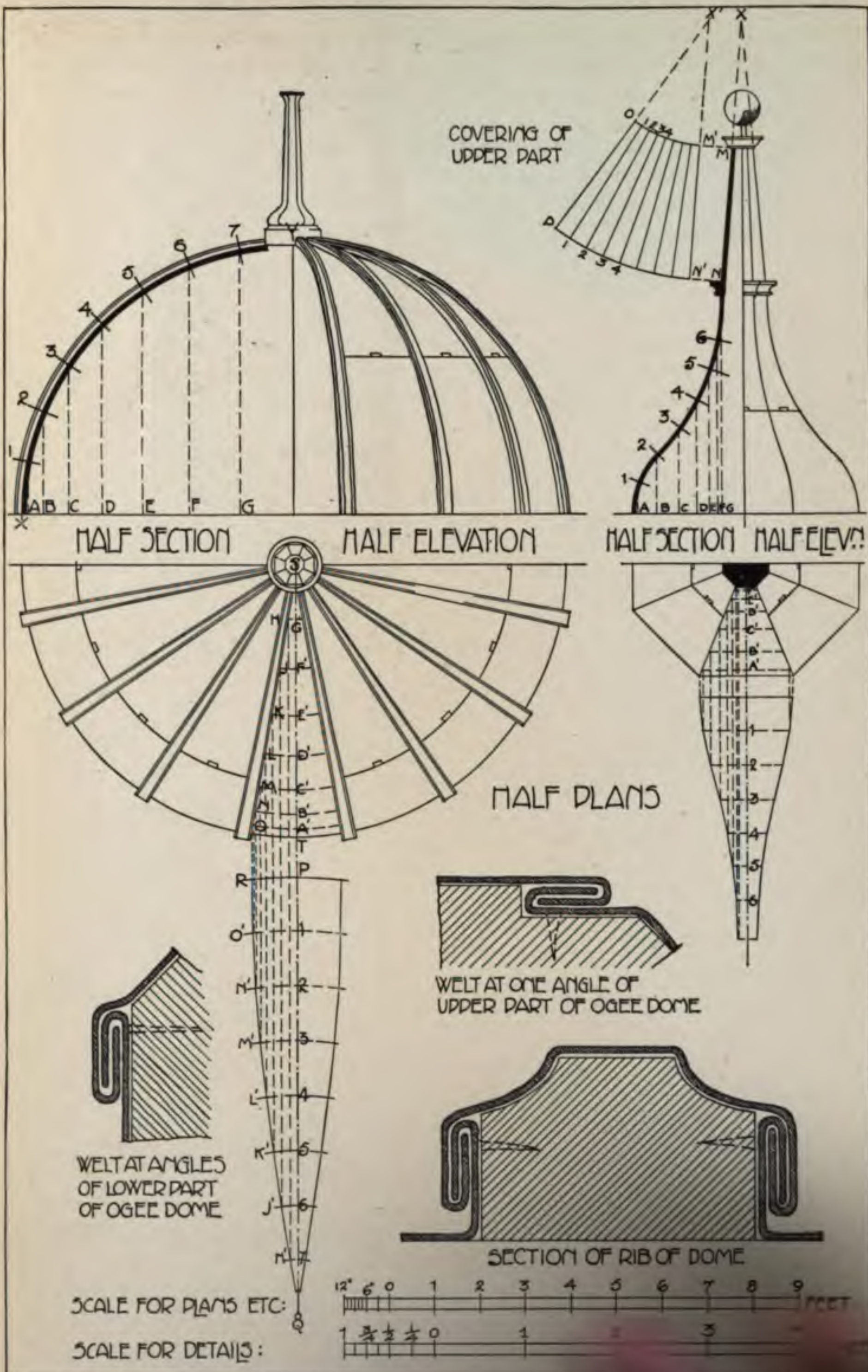
It is necessary to provide a gutter inside the grating of the ventilator in order to catch any rain that may be blown in by the wind. The outlet should be brought through the side, and made good by a wiped joint as shown.

Covering of Domes (Plate IX).—Public buildings are now being designed of a more elaborate character, and domes and towers enter to a very large extent into schemes where prominent features are required on roofs.

The method of treating the lead, as shown in Plate IX, is applicable to most forms of domes, towers, or spires, so far as the setting-out of the bays is concerned. Where something of a bolder character than an ordinary roll is wanted, the rib shown in the plate can be used or varied in many ways. One of the advantages of a strong rib is the facilities it gives for securely fixing the lead. In this case the sides of the bays are turned up to the ribs and secured by strong copper nails with large flat heads, and the top edges against the ribs are welted to the rib cover, as shown in the section. The lead forming the cover to the rib is left straight over the hollow while the welt is being turned, after which the hollow is worked-in by a round dresser; this has the effect of pulling the welts tight.

The bays should be fixed in at least two pieces with a lap in the middle. In such a case no secret tacks are necessary.

The angles of the ogee dome, shown on the same plate, can be welted, and either raised or sunk as shown in the sections, or a roll can be arranged at the angles in the manner shown in fig. 155. The upper part can be



DOME AND TURRET COVERED WIT

covered in one piece with a welted seam on one of the angles, and the neck-moulding be covered separately. The lower bays can be in single lengths, but they would be none the worse in two, with a lap near the centre as shown. The fixing, in this case, would depend on the sheet-copper tacks folded in the welts, and the nailing at the top edges of the bays.

To set out the templates of the bays geometrically the following methods may be employed:—

To find the covering of a hemispherical dome:—Divide the arc X Y on the section into any number of parts, numbered 1, 2, 3, &c. From the numbered points draw lines 1 A, 2 B, 3 C, &c., perpendicular to the base line. On the plan, draw the semi-diameter S T, bisecting one division of the dome, and set off upon it from T the divisions A′, B′, C′, corresponding to A, B, C, &c. on the section. Produce the diameter S T indefinitely. From any point P make P Q equal to the length of the arc X Y, and extend upon it the divisions 1, 2, 3, &c. From the centre S describe the arcs A′ O, B′ N, C′ M, &c., and from Q as centre describe arcs through the points P, 1, 2, 3, 4, 5, 6, 7. Make P R equal to half the width of one gore or division of the dome at the base; make 1 O′ equal to A′ O, 2 N′ equal to B′ N, 3 M′ equal to C′ M, and so on. The curved line R Q, passing through the points O′, N′, M′, &c., will be one edge of the gore, and of course the other will be found by setting off the distances P R, 1 O′, Q N′, &c., on their respective arcs on the opposite side of the centre line.

To find the covering of the lower part of the octagonal ogee dome, the process is very similar, except that the lines passing through A′, B′, C′, 1, 2, 3, &c., are straight lines instead of arcs. The upper part is covered in one piece and the development of it is shown. Produce the sides till they meet at X. From any point X′, draw the straight line X′ M′ N′ equal to X M N, and with radii equal to X M and X N, describe the arcs M′ O and N′ P. Set off on these arcs the width of the sides of the octagon at the top and bottom respectively, and join these points and the points O P by straight lines.

The shape of the lead is shown by the outline M′ N′ P O, and the angles of the octagon by the lines 11, 22, &c.

After the shapes of the bays have been obtained, margins should be left on the two sides to form the undercloaks and overcloaks of the welts or rolls, as the case may be.

CHAPTER VIII

LEAD COVERING FOR CORNICES

The protection of the tops of stone cornices, and stone and brick strings, by sheet-lead coverings, is more than ever recognized as necessary in order to prevent the deteriorating effects of rain and frost. The lead covering of a stone cornice is all the more necessary when a gutter is formed on the top in order to prevent the rainwater from running over the front

edge. Such an arrangement is shown in fig. 162. In many cases it is a difficult matter to lay the lead in such a way as to give the necessary play for expansion and contraction, but this point is not so important on a stone cornice as on a boarded roof, because, the stone being a better conductor of heat than boarding, the lead is not affected to anything like the same extent as in gutters or on flats. If it were possible to construct drips at frequent intervals in the cornice-gutter there would be no difficulty, but as a rule the requisite depth is not available, and the lead has to be joined either by soldering or by burning, as the flat welts, which would be quite suitable in the case of a cornice like fig. 165, would be entirely out of place in a gutter, where the welt would be sometimes under water, and could not be relied upon to be water-tight.

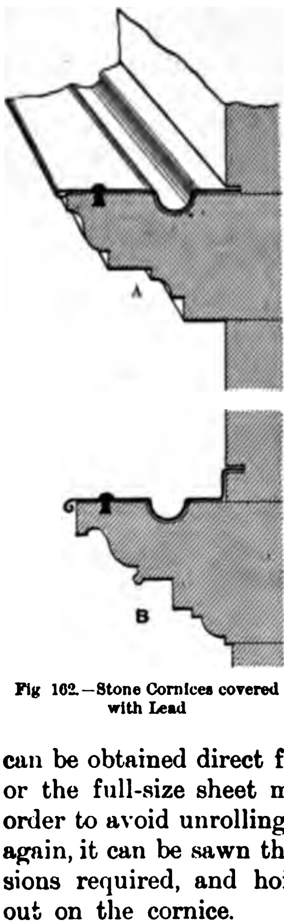


Fig 162.—Stone Cornices covered with Lead

To avoid Soldering.—For the purpose of avoiding soldering or burning, or at any rate to reduce it to a minimum, the cornice is covered with long pieces of lead, sometimes the whole length of a sheet, which is generally 32 ft. long. Pieces of this length, and of the necessary width, can be obtained direct from the lead-works, or the full-size sheet may be used, and, in order to avoid unrolling it and rolling it up again, it can be sawn through to the dimensions required, and hoisted up and rolled out on the cornice.

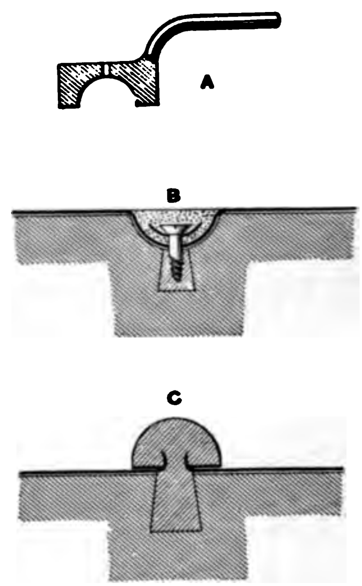


Fig. 163.—Cast-lead and Soldered Dots

A, Dot-mould; B, Soldered Dot; C, Cast-lead Dot.

Finishing the Edges.—There are different ways of finishing the front and back edges. A welt is sometimes formed on the front edge, as at A, fig. 162, or a bead is turned on it, as at B. The back edge is slipped into a groove or joint either level with the top of the cornice, as at A, or about 3 in. above the cornice, as shown in the section B. The latter is the better arrangement, as the lead forms a weathering.

Cast-lead and Soldered Dots.—The lead is held down near the front by cast-lead dots, which are also shown in the section. These should be run into well dove-tailed holes in the stone, and moulded on top by a brass or iron dot-mould, of the kind shown at A, fig. 163. Until comparatively

recent years soldered dots were used for this purpose, and, although they answer their purpose better in this case than for holding sheet-lead on wood-work, they are not so suitable as the cast-lead dots. It may, however, be well to describe the formation of a soldered dot for this purpose. In addition to the dove-tailed hole, a sinking is required similar to that shown in the section at B, fig. 163. The copper or brass screw, the head of which should be tinned, should be held by a pair of pincers in the hole while this is being filled with molten lead. When this is set, the screw should be turned out, and when the sheet-lead covering is in its place, and bossed into the sinking, the margin soiled, and the sinking shaved, the screw should be replaced with a tinned copper washer under the head. If the stone is dry, the solder can be poured into the sinking and on the surrounding surface, until there is sufficient heat to effect the tinning of the lead, and the solder can then be wiped flush with the surface as shown. But if the stone is somewhat damp, it is advisable to lay one or two thicknesses of brown or other paper between the stone and the lead, or it will be found very difficult to wipe the surface of the solder clean and regular, even if an iron is used to assist in retaining the heat and to facilitate the tinning.

In the case of the lead dots the difficulties of the soldered dot are avoided. No sinking beyond the dove-tailed hole is required, and, excepting that the hole in the sheet-lead should be made very small and a slight ridge raised in the manner shown at C, fig. 163, no other preparation is necessary. If the stone is very damp, it is a good precaution to use the paper as above mentioned, and a little resin should be placed in the hole before the lead is poured in, as this acts as a flux, and causes the lead to run more freely and so fill the hole completely. It will be noticed that a small tag of lead will be left on the top of the dot, in the form of the pouring-hole in the mould, but this can be cut off with a knife and smoothed by a few taps with the face of a hammer or mallet.

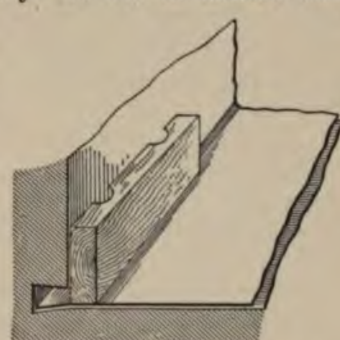


Fig. 164.—Method of Burning Lead in Groove of Stonework

Burning-in the Back Edge.—When the joint is level with the surface of the cornice, as at A, fig. 162, there is an opportunity for the rain to soak into the joint, particularly if it is pointed with cement, as this is liable to be disturbed by the movement of the lead, which is sure to take place more or less. In such a case the burning-in process is the best system to adopt. This process consists of filling the groove with molten lead, instead of merely driving a lead wedge in about every 2 ft. and filling the groove with cement. Sometimes mastic is used for this purpose, and it is much more suitable than cement. The "burning-in" is done by fixing a piece of board [illegible] long, which has been shaped for the purpose, in front of [illegible] by the section, fig. 164. Two pouring-grooves [illegible] the point opposite the groove in the stonewor[illegible]

have been stopped with clay, the lead is poured into both grooves at the same time until the joint in the stone is filled. When this process has proceeded for several feet, the lead is caulked into the joint carefully by means of a caulking-tool, and then the surface is cleaned off by the use of a flat rasp and shave-hook. A good deal of time has to be expended on this process if it is to look neat when finished, but if it is done properly it is well worth the time and labour involved.

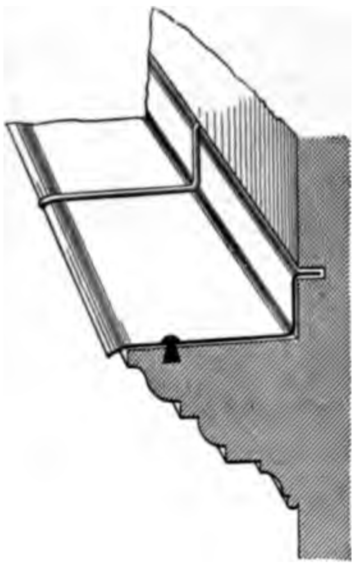


Fig. 165.—Welted Seam in Lead Covering of Cornice

When the lead is turned into the groove 3 in. above the cornice, the "burning-in" is not so important, as the joint is well above the surface, and is not so likely to allow the water to soak into the stonework, even if the pointing happens to be slightly disturbed.

Welted Seams.—When the lead covering is arranged to fall to the front edge of the cornice, as in fig. 165, long pieces of lead can easily be avoided, and there can be no doubt that the smaller the pieces the more durable is the lead in all cases. The usual plan is to form a seam by means of a flat welt about every 7 ft., as this is the width of a sheet, and it is also a convenient size for cutting out and for handling. If it is desired to dispense with dots, the pieces of lead should be cut to about half the length last mentioned, and sheet-copper tacks can be fastened to the stone in the same manner as that described for the soldered dots, and folded in the welts about 6 in. from the front edge.

CHAPTER IX

LEAD RAINWATER PIPES AND HEADS

Lead and Iron Compared.—Many years ago lead was regarded as the only suitable material for rainwater pipes and heads. Many of these still exist, and are generally found to be in good condition after being in use for a century, and in some instances for a much longer time. During recent years, however, cast-iron has almost completely superseded lead for rainwater pipes. But iron has been in use long enough now to enable architects to realize that, although iron pipes are cheapest, so far as the first cost is concerned, in the long run lead is far more economical. For not only have cast-iron pipes been found to decay very rapidly, especially at the back, where they are not accessible for periodical painting, but the damage which has been caused to fine buildings by leakages from these

pipes has involved an expense far beyond the difference in cost between lead and iron.

The Old Style.—On ancient buildings the pipes were made up by plumbers entirely, the sheet-lead being cast on the old-fashioned casting-bench, turned up on mandrels to the shape required, and the seam at the back soldered either by wiping, which is the most substantial method, or by what was known as a drawn seam, or in some cases by a copper-bit seam. The latter must always be regarded as the least substantial, excepting where the seam is made more than usually wide and thick. It is only during more recent years that the seams have been made by the burning process, and when this kind of seam is adopted it is important that, like the copper-bit seam, it should be made very substantial.

Drawn-lead pipes can now be obtained either round, square, or rectangular, and therefore pipes with soldered seams at the back are not often required. As, however, the square and rectangular pipes are made in only a few sizes, it sometimes happens that, for pipes of a special size and shape, the old-fashioned process has to be adopted, the lead being turned up on mandrels, and a seam formed at the back. The demand for cast sheet-lead rainwater pipes, which is being revived to some extent, also involves the use of soldered or burnt seams.

Drawn-lead Pipes.—When the pipes are drawn in the modern style, without a seam, there is very little for the plumber to do beyond forming the socket and soldering-on the astragals and tacks. When only a simple form of socket is required, a mandrel is made of a size suitable for a socket into which the spigot end will slip easily, and cast astragals are soldered-on by what is known as "sweating"; that is, the inside edge of the astragal is tinned, and the outside of the socket is also tinned just where the astragal is to be fixed; when this is in position, fine solder is sweated between the two faces by means of a blow-lamp. The mitres should be soldered in the same manner. A view and two sections of such a socket are shown in fig. 166.

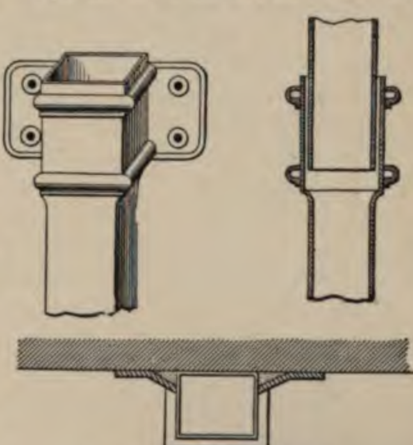


Fig. 166.—Lead Rainwater Pipes

The tacks should be securely fixed by a deep wiped soldered seam, as shown in the cross-section. When the lengths do not exceed 6 ft., and are not more than usually heavy, no more fixing than a pair of stout cast-lead tacks, with two galvanized-iron or copper nails, is necessary. But if the pipes are made out of lead more than 8 lb. to the square foot, and larger th 4 in. by 3 in., some additional fixing is advisable. A pair of small ear the centre of each length, as shown at A, fig. 167, ought not to objectionable appearance; but, if a hidden fixing at B is very suitable. It consists of a gun-me

projecting end having an eye. On the back of the pipe is sweated a double-eyed bracket which fits on each side of the staple, and a pin or bolt is put through the eyes, and thus forms a firm fixing. The advantage of this form of fixing is that the pipes can be fixed by starting above or below; but if the simple hook-and-eye style is used, it is necessary to start from the bottom, each succeeding length being dropped down vertically, so that the eye or socket drops on to the hook. The latter is, of course, the simplest, provided there is no difficulty in starting the pipes from the bottom.

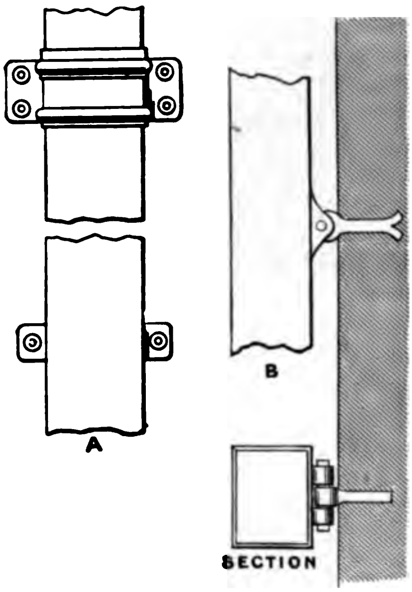


Fig. 167.—Methods of Fixing Lead Rainwater Pipes

When **bends** or **set-offs** are required on drawn square pipes, they are usually made in the form of elbows; but where a curved form of bend is specially required, it has to be made on a piece of round lead pipe of a circumference equal to, or a little larger than, the girth of the square pipe, and the angles squared-up in the ordinary way after the bend is made. The squaring-up is done on square mandrels or square bobbins, which are driven through the pipe while the angles are dressed.

In forming angular elbows (fig. 168) the mitres are cut with a saw, and have to be neatly soldered, or, better still, burnt, so that the seam is not shown. The mere sweating of the square edges of the lead together, in order to form a secret joint by soldering, is not strong enough to be relied upon. If it is done in this way, a strip of lead about 1 in. wide should be shaved and tinned and placed inside the elbow joints as shown, and the inside edges shaved and tinned a corresponding width. It can then be well sweated, and a reliable joint is formed without any solder being seen, except a very fine streak at the mitres.

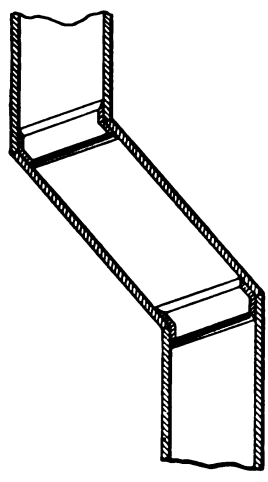


Fig. 168.—Angular Elbow or Set-off

When **sockets** and **tacks** on lead rainwater pipes are required of a more elaborate design, they should be cast in one piece, similar to that at A, fig. 169, and sweated or burnt to the pipe, whether this is of drawn- or cast-lead. This can be done by slipping the pipe into the lower end of the socket about 3 in., after carefully preparing and tinning the inside of the socket and the outside of the end of the pipe. Then, by the aid of a blow-lamp, fine solder can be "sweated-in" between the two tinned surfaces, as shown

in the section B. The most reliable method, however, is to let the pipe pass right through the socket, and to solder it at the top edge as shown in the section C, forming a V-shaped joint about 1 in. deep, and "sweating" the solder about 2 in. below that to ensure a thoroughly reliable connection between the socket and the pipe.

Lead rainwater heads are made in various ways. The old-fashioned style was to boss the fronts on a wooden block, or on a metal mould made of solder or "hards", that is to say, old solder and lead together. The

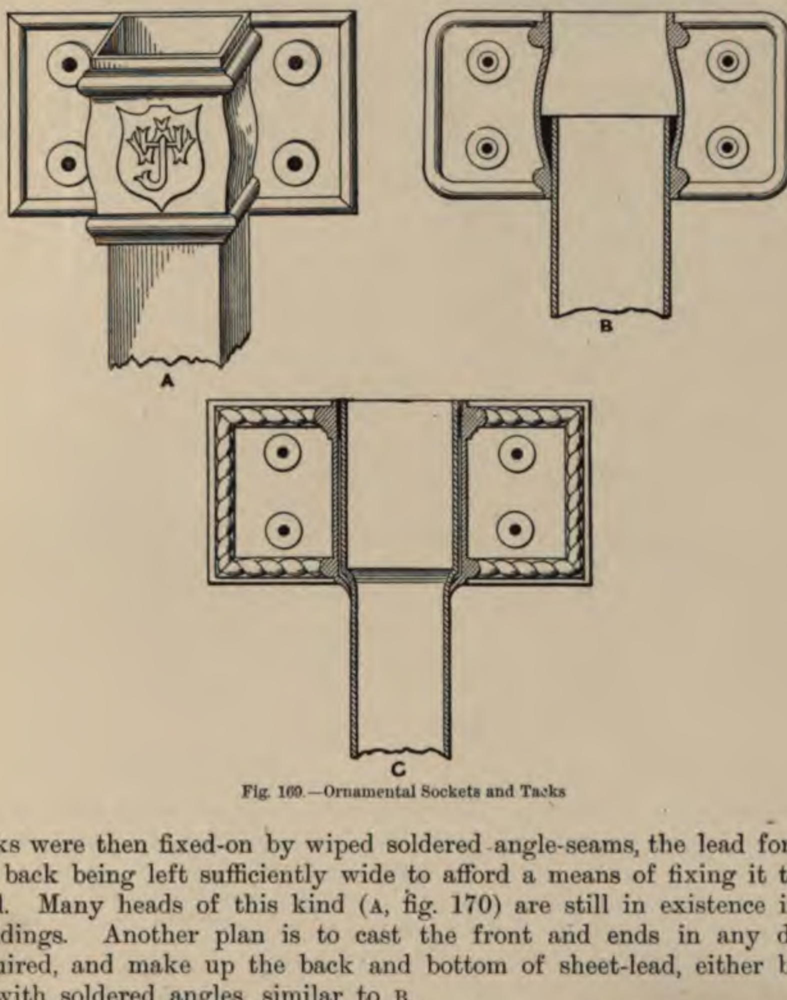


Fig. 169.—Ornamental Sockets and Tacks

backs were then fixed-on by wiped soldered angle-seams, the lead forming the back being left sufficiently wide to afford a means of fixing it to the wall. Many heads of this kind (A, fig. 170) are still in existence in old buildings. Another plan is to cast the front and ends in any design required, and make up the back and bottom of sheet-lead, either bossed or with soldered angles, similar to B.

Many of the old and some modern heads are made of sheet-lead, either cast or milled, and the mouldings and other enrichments are cast, and soldered or burnt on the body of the head. Such a head is sh
Some are bossed up entirely out of one piece of sheet-lead, and
worked by hand without a mould. That shown at D is a specim
which have been bossed by students at plumbing-classes condu

writer. The lead is first cut circular, and the bossing takes the form of a basin, which is then developed into a kind of funnel, the outlet being formed by cutting a small hole in the bottom and bossing it out to the size required, and rounding it up on a mandrel. The design is then bossed out from inside, and chased on the outside with box-wood chase-wedges. As

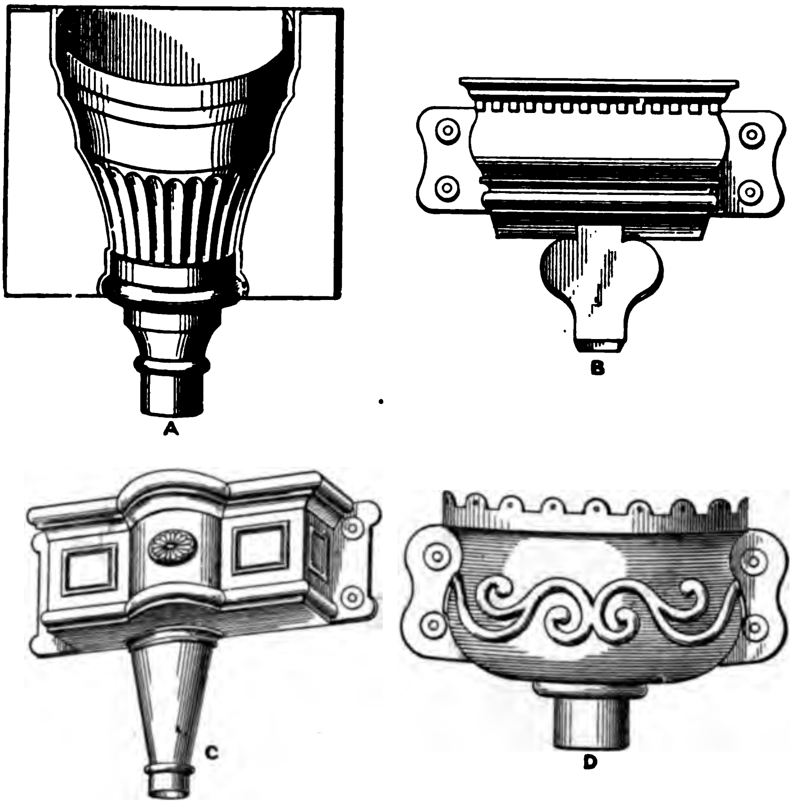


Fig. 170.—Lead Rainwater Heads

far as the plumber is concerned, this is the most artistic method of making lead heads, but generally it takes more time than is considered reasonable for this class of work, and where there are several of the same design the casting method is, of course, less costly. But if only one is required, the bossing method is as economical as casting.

The tendency now is to make all the heads on a building to the same pattern, and it is usual to cast them in one piece. Generally speaking, plumbers have very little to do with this work, which is now done almost exclusively by metal-founders.

CHAPTER X

LEAD SINKS AND CISTERNS

Sinks.—Although lead-lined sinks are to a large extent being superseded by those of wood or fire-clay, many people still prefer them, especially in sculleries and pantries, where large quantities of crockery have to be washed. Lead sinks can be made much more durable than they are usually supposed to be, providing the wood-work is substantial, the lead is reasonably thick and the soldered seams strong.

In the case of a washing-up sink about 3 ft. × 2 ft. × 1 ft. deep, the bottom should be 2 in. thick, and the sides not less than 1½ in. The angles should be dove-tailed, and the bottom screwed on. The lining of lead should be not less than 12-lb. lead for the bottom and 10-lb. for the sides, and the angles should be soldered about 1⅛ in. wide on each side, and have not less than 1½ lb. of solder to the foot run. One side and end should be lined with one piece, thus requiring two soldered upright angles; all the bottom angles must be soldered. The lead for the sides should be set out and the angles prepared on the bench before the two angles are bent. A margin of ½ in. should lie on the bottom, and the top edge should turn over on the top of the sink, as shown in the section, fig. 171. The bottom should now be prepared in the same way, with a margin on the edges of about ¼ in., as shown in the section. The lapping of the two margins prevents the solder from running through the joint and getting between the wood-work and the lead, and also has the effect of keeping the lead in its place, without the aid of nails, while the soldering is being done. All that is necessary, in addition to the laps, is a few holes, about 3 in. apart, made with a nail-punch (similar to that used by carpenters), in the edge of the outside lap. If these holes are made just a little deeper than the thickness of the lead, they effectually keep the lead in its place. But if nails are used, especially clout nails, blow-holes are formed as the soldering proceeds, with the result that the wiping-cloth has to be drawn over the seam after it is properly formed, and this causes the surface of the solder to become rough and dull, instead of being smooth and bright.

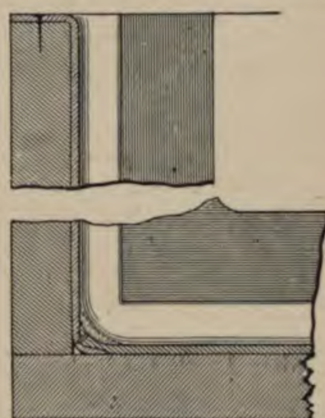


Fig. 171.—Vertical Section of Lead-lined Sink

The top edge is then dressed over the top o[illegible] opper-nailed, and trimmed off flush with the outside fa[illegible]

Soiling and Shaving.—It is much the best [illegible] ne edges of the lead on the bench before it is [illegible] should be about 6 in. wide, and the sha[illegible] 1⅛ in. wide each way from the angle.

with tallow, as a flux, it is ready for soldering. It is the usual plan to place the sink on its side or end while the upright angles are soldered, as the wiping can be done much more conveniently than when they are in a vertical position.

Soldering.—If the solder is fine, and well heated before it is splashed on the angle, it can be wiped without the aid of an iron or blow-lamp, provided sufficient solder is used, so that a good heat is obtained before the wiping is started. But if the solder is somewhat coarse, it is advisable to use a plumbing-iron to assist in keeping up the heat while the wiping proceeds. A well-soldered seam should lie straight and regular, the edges being wiped clean, and the surface should be bright when cool.

After the two upright angles are finished, the sink should be placed on its bottom and the bottom angles wiped. In order to prevent the lower ends of the upright angles being disturbed, some pieces of paper should be pasted over the solder about 3 in. long and down to the line of the bottom seam, and removed when the soldering is finished.

Other Methods.—A still more durable method of lining sinks of this kind is to cover the bottom with a cast-lead plate about ½ in. thick, instead of the ordinary milled sheet-lead, but in other respects the lining is similar to that above described. The excessive expansion and contraction which always takes place in lead-lined sinks which are supplied with hot water, does not affect cast-lead to the same extent as milled lead, especially when the former is of substantial thickness.

Where it is not convenient to obtain a lead plate, another excellent plan is to line the bottom with sheet-copper, and solder the angles in the same way as for lead. The copper should be prepared by cleaning and tinning the edges to the required width before it is put in its place, and then the wiping can be done in the ordinary way.

Cisterns.—When cisterns have to be lined with lead, the process is similar to that adopted for sinks, but in most cases the upright angles have to be soldered in a vertical position, and this requires more skilful handling.

Methods of Wiping Vertical Angles.—When the cistern is small enough to be placed in any convenient position, so that the angles can be soldered horizontally, as in the case of sinks, the wiping is one of the simplest forms of soldering; but when the angles are wiped upright, it is only after considerable practice that a plumber can wipe them regular and clean. If they are not more than 3 ft. high, the whole length should be wiped in one heat —that is to say, the whole length should have the solder "splashed" on at the same time and wiped from the top to the bottom without a break. In order to prevent the solder, which falls to the bottom, from tinning on the lower angles, a piece of board about 9 in. × 9 in. should be fitted close into the angle, as at A, fig. 172, and not removed until the wiping has reached within a few inches of the bottom. The bottom angles are then free from superfluous solder, which would otherwise be in the way and difficult to remove.

If the cistern is deep and the vertical angle 5 ft. or 6 ft. long or more, the soldering should be done in two sections, the top in all cases to be

wiped first. And to prevent the surplus solder from falling on the lower part of the angle and on the bottom, a piece of board should be placed at the required height, and held in its position by a wooden strut nailed or screwed to the board, as shown at B, fig. 172. When the upper part is soldered, the board is removed and placed on the bottom as mentioned above. With regard to the manipulation of the solder, it is important that it should be fairly fine and of good quality. If the tin is good, the usual proportions of 2 of lead and 1 of tin will be found to work satisfactorily.

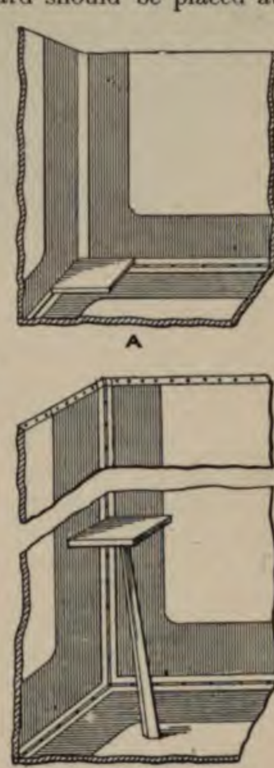


Fig. 172.—Methods of Wiping the Vertical Angles of Cisterns

The solder-pot should always contain not less than ¼ cwt., and should be well heated before it is removed from the fire. In some cases, where a supply of gas is available, and the cistern is in a convenient position, the pot is kept hot on a gas-stove, so that the heat is retained as long as it is required. The petroleum-stove is also found very useful for this purpose, but is not so safe inside a building.

The solder should be splashed on to the angle with an iron "splash-stick", with smooth edges, so that it does not scratch the soiling, and a good heat should be obtained before the wiping is commenced. This should be done with a thick cloth about 3½ in. square, so that a good margin extends over the edges of the shaving line. The seam can now be wiped in a downward direction in strokes about 6 in. to 8 in. long; and although a skilful wiper can dispense with the use of an iron or any other means of retaining the heat, in most cases something of the kind is necessary. But nothing is more suitable than the old-fashioned plumbing-iron well heated and carefully cleaned. The iron should be well rubbed into the solder in an upward direction, and followed up with the cloth, at the same time patting the solder together into the angle. Then with rapid strokes the edges on each side should be cleared of solder, and the centre finished last. When the upright angles are finished, those at the bottom are soldered in the manner already described.

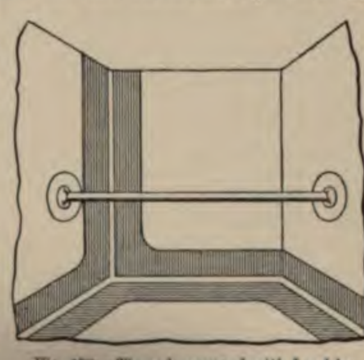


Fig. 173.—Tie-rods covered with Lead in ·erns

Tie-rods.—In large cisterns tie-rods are required to prevent the sides from bulging. These consist of wrought-iron rods bolted through the two sides and covered by lead pipe, which is soldered by a flange-joint at e lining, as shown in fig. 173. These must neces linary

position. The ends of the pipe are shaved about 1¼ in. long, and the shaving on the side of the cistern is about the same width. The solder is splashed on, the surplus being caught by a board, which is strutted up underneath the joint. After a good heat has been raised by the solder, the wiping should commence at the bottom, either one side or the other, and proceed in one direction over to the other side, and finish off at the bottom.

Soldered Dots.—When the cisterns are unusually large, it is often necessary to provide some means of preventing the lead at the sides and ends from bulging outwards from the boarding. The simplest means is that of soldered dots, which in such a case are not so objectionable as on roofs, because the expansion and contraction are much less in a cistern, although a gradual expansion and consequent bulging very often takes place. The soldered dot already described (fig. 126) is suitable for this purpose.

Pipe Connections. — When cleansing waste-pipes are required in lead-lined cisterns, the hole through which the pipe passes should be countersunk in the manner shown in fig. 174, and the end of the pipe tafted over in the form

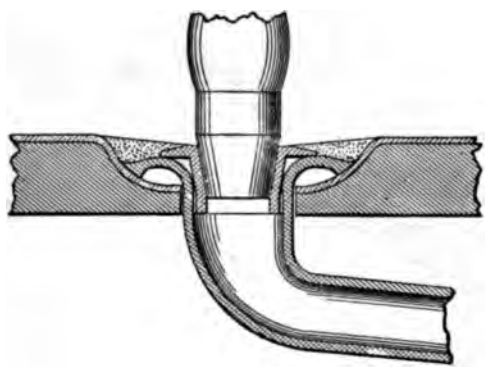


Fig. 174.—Waste Outlet in Cistern

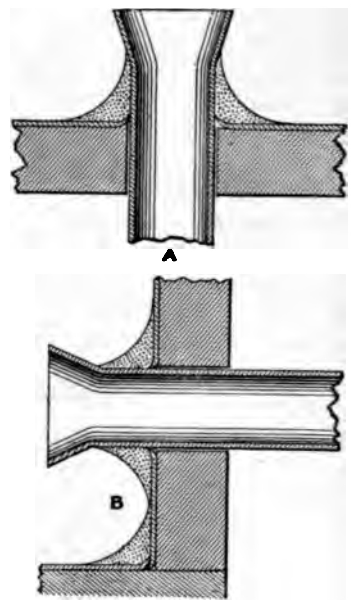


Fig. 175.—Service-pipes in Cisterns

of a round bead; and, after the brass washers are properly tinned and placed in position, the wiping should be flush or, if anything, have a little slope to the outlet, as shown. Service-pipes are either soldered in the bottom, as at A, fig. 175, or taken through the side, as at B. The soldering of the joints needs no description, but care should be taken thoroughly to tin the solder to the lead by getting up sufficient heat before the wiping is begun. In many cases it has been found that, in soldering the joints in the bottom of the cistern, the solder has been splashed on so sparingly that the mere rubbing over the surface with an iron, or wiping it without one, has not caused the solder to cohere with the lead (or to "tin", as it is usually called), with the result that when the cistern is filled with water the joints leak. These joints are generally regarded as the

simplest and easiest to make, but they are often the least reliable, not only in cisterns, but in other parts of plumbers' work.

The Ball-valve.—Another important thing about lead-lined cisterns is the fixing of the ball-valve. In most cases the end of the rising main is very insecurely fixed on the top edge of the cistern. The best method of fixing is to turn the end of the rising main through the side, as shown in fig. 176, cut the brass screw-boss short, and secure it by a flange joint. The ball-valve is then below the top of the cistern, and the cover can be made to fit quite dust-tight, whereas in most cases a hole has to be cut through the cover to allow the ball-valve to work.


Fig. 176.—Connection of Rising Main to Cistern

The overflow-pipe should be formed with an oval-shaped mouth, the area of which should be nearly three times the area of the pipe, in order to carry the overflow water away quickly. This has the effect of thoroughly charging the pipe before the water rises above the top of the mouth, as it would do if the pipe terminated with its ordinary area at the side of the cistern. The joint can be made in two or three ways. Fig. 177, A, shows the mouth of the pipe projecting straight into the cistern, and the joint wiped around the outside. At B the mouth is tafted over in the form of a bead, and wiped, as shown, or it can be countersunk and wiped flush, as shown at C.

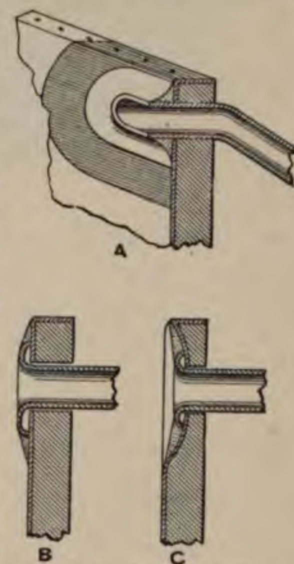


Fig. 177.—Overflow-pipes in Cisterns

CHAPTER XI

LEAD AND ZINC COFFINS

There are various ways of making lead coffins. The old method was either to cast them in one piece, and solder-on the lid, or to cast the sides, ends, bottom, and lid in separate slabs, and solder the sides, ends, and bottom together on the inside angles, and the lid from the outside. But during recent years the inner wooden "shell", as it is called, is covered on the outside, or the coffin proper is lined in very much the same manner as a sink or cistern, and, after the inner shell has been placed inside, the lead cover is soldered at the outside edges.

The most common method, however, is to cover the wood shell i manner shown in fig. 178. Grooves are formed on the bottom outside angles, as shown in the section A, and in the

The bottom is in one piece, and the edges are dressed into the grooves. The sides and half the ends are made in two other pieces, and the edges also dressed into the grooves and bossed over the corners at the bottom and at the ends, and the top edge is dressed over the edge of the shell and over a chamfered edge on the inside as shown in the section A.

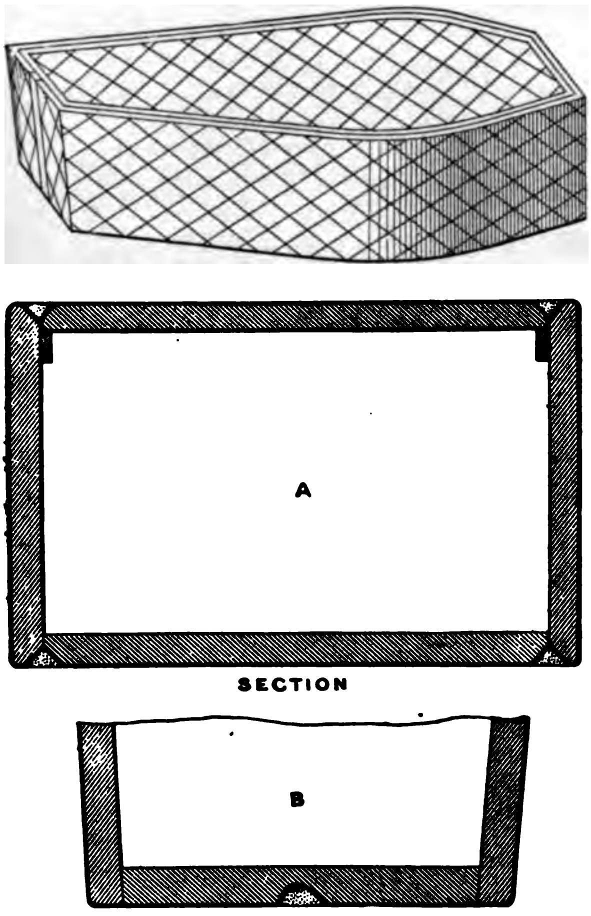


Fig. 178.—Lead-covered Coffin

As in most cases the lead covering on this shell is cleaned up and brightened with wire-card, the ordinary black soil is not used in preparing for soldering, but instead the lead is well chalked and then rubbed with raw potato. The potato, being starchy, forms, in combination with the chalk, a sufficient protective coating, and prevents the solder from tinning beyond the edge of the shaving. The seam is then wiped flush in the ordinary way, and, when the chalk has been washed off, the whole of the surface is scoured with wire-card.

It was at one time the custom to score the surface diagonally with the prongs of a steel fork, which gave it the appearance shown in fig. 179.

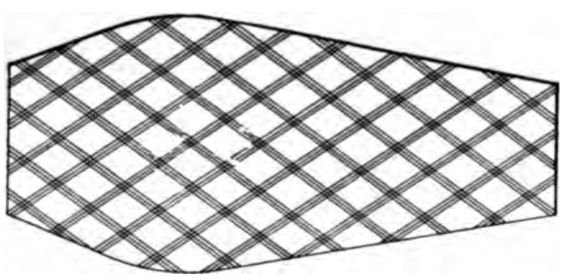


Fig. 179.—Diamond-pattern Scoring on Lead Coffin

In covering the lid the lead is dressed over the edges, and copper-nailed underneath or on the edge, and is scoured and lined in the same way as the shell.

When the body is in the shell, the lid is placed in its position and the

seam soldered flush, after which the lid of the outer case is screwed down.

The substance of the lead varies, but the usual weight is 5 or 6 lb. to the foot. The soldered seam is generally somewhat light, about ½ lb. of solder to the foot being considered sufficient.

When the outer case is lined with lead, the shell is placed inside; and as it does not fix tight to the sides of the case a supplementary wooden lid should be made to fit the case exactly, just below the top edge.

Fig. 180.—Vertical Section through the Finished Coffin

The lead cover is then put in as shown in fig. 180, and a seam is wiped in the angle, the sides of the inner lining being left standing upright. In such a case no scouring of the lead is necessary, as the outer lid is screwed on immediately after the "soldering-down" is done.

Zinc Coffins.—It is very rarely that any other kind of metal is used for this purpose in this country, but on the Continent zinc is often used. In making a zinc coffin the process is similar to that adopted for lead, with the difference that the corners cannot be bossed, and have, therefore, to be cut and soldered. The soldering, also, is of a different character; this has to be done with a copper-bit and fine solder, using chloride of zinc or "killed spirits of salt" for a flux. Most of the soldering fluids which can now be obtained ready for use can also be used for fluxes.

CHAPTER XII

SHEET-LEAD SAFES

Lead safes are generally laid on wooden floors under cisterns, water-closets, baths, &c., and are sometimes known as "safe-trays" or "drip-trays". In all properly-arranged plumbing works something of an impervious nature is necessary in order to prevent condensed water, leakages, overflows, and splashings from the various fittings saturating the floors and ceilings beneath them.

Safes under Cisterns.—Where the floor under a galvanized-iron cistern is not constructed of concrete, and the surface cemented or asphalted, the wooden platform should be covered with a 5- or 6-lb. lead safe, the outer edges of which should project about 6 to 9 in. beyond the sides of the cistern.

Where the cisterns are situated over important rooms, the lead safe is a sure protection against the effect of drippings from condensed vapour, sudden leakages from the cistern or stop-valves, and also overflows that may be caused by the action of frost when the overflow-pipe has become blocked with ice. Such an effect is often caused by a slight defect in the

ball-valve, the leakage being so small that the water freezes as it passes through the lower end of the overflow-pipe. It is therefore important that the safe should be provided with a waste-pipe quite independent of the overflow-pipe from the cistern.

In many cases the overflow-pipe is taken into the safe waste, as shown in fig. 181, and where the cisterns are not in exposed positions this plan may be satisfactory. But where the cisterns are in the upper roof of a

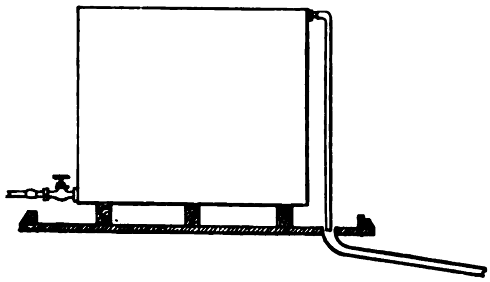


Fig. 181.—Cistern-overflow and Safe-waste combined

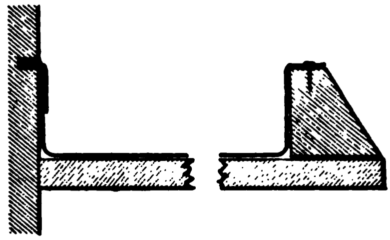


Fig. 182.—Lead Safe with Flashing and Wood Curb

house which is exposed to cold winds, it is much the best plan to take the two pipes through the wall or roof quite separately.

Where the sides of the safe are not against a wall, a substantial wooden curb should be fixed about 4 in. deep, as shown in the section (fig. 182), and the edge of the lead turned over the top and close copper-nailed. If the safe stands against a wall, the top edge should be flashed (fig. 182) in the same manner as the stand-up of a gutter. This flashing is as a rule not considered necessary, but the writer has known cases where a defective ball-valve has thrown a jet of water over to the face of the wall, and the water has run down the wall and behind the edge of the safe. A flashing would obviously have prevented this.

The size of the waste-pipe from the safe must depend on the size of the rising main and the velocity of the incoming water. As a rule safe-wastes are absurdly small. If proper precaution is to be taken, this pipe should be at least twice the diameter of the rising main, and should never be less than $1\frac{1}{2}$ in. in diameter. It should have an easy bend under its connection to the safe, and the mouth should be opened to form a funnel, the mouth of which ought to be about twice the diameter of the pipe, as shown in fig. 183. It should also have as rapid a fall as practicable.

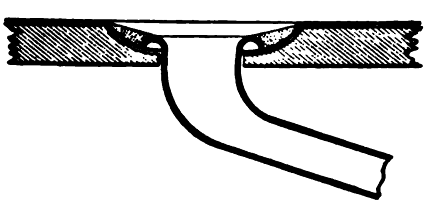


Fig. 183.—Connection of Waste-pipe to Safe

In a country house where the storage cisterns are filled quickly by a pump worked by engine power, both the overflow from the cistern and the safe-waste should be more than usually large, as a stoppage in the overflow-pipe from the cistern would cause the safe to be flooded very quickly.

Lead safes under water-closets are not only necessary to prevent damage,

but also from a sanitary point of view, when they are fixed on wooden floors. During recent years, however, water-closet floors have often been constructed of impervious materials such as tiles, marble, asphalt, and glazed fire-clay. In such cases the lead safe is not required. But to fix water-closets of any kind on bare wooden floors is most objectionable, whether the water-closet is fitted with an enclosed seat or is of the pedestal form.

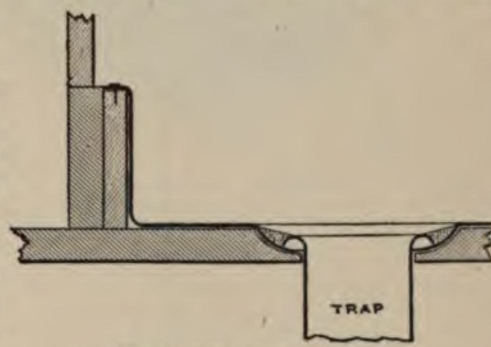


Fig. 184.—Safe under Valve-closet

It is true that the improved styles of **valve-closets**, with slop-top basins and properly-fitted seats and enclosures, render the safe of less importance, but even then leakages may occur, and the floor is likely to become thoroughly saturated with water before the defect is discovered. In such cases lead safes should cover the whole space within the enclosure; the turn up of 4 in. should be dressed close to the wall at the back and sides, and the front edge should be dressed close to the riser and close copper-nailed. A better plan is to fit a $\frac{3}{4}$-in. board on edge against the inside of the riser, and turn the edge of the lead over the top and secure it with copper nails, as shown in the section (fig. 184). The waste-pipe should not be less than $1\frac{1}{4}$ in. and on most first-class works it is $1\frac{1}{2}$ in. in diameter.

In the case of **pedestal closets**, the lead safes on wooden floors are most important, not so much on account of leakages, because as a rule these proceed from the flushing cistern, which has its separate overflow-pipe, but because the splashings of slops, and the effects of the water-closet being used as a urinal, in numerous instances cause the floor to become saturated with foul matters, which cannot be removed by cleaning. The foul liquid will often be found to have run down the sides of the pedestal, and soaked under the base, where it remains to create a nuisance.

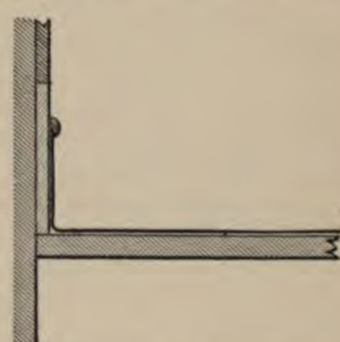


Fig. 185.—Stand-up of Safe against Cement or Tiles

As the safe is required to catch the splashings and drippings only, there is no need to make it deep, and in most cases, indeed, it would be inconvenient to do so. The safe should turn up against the wall about 3 in., and be copper-nailed to the skirting. But if the skirting is of cement instead of wood, the top edge of the lead should be covered with a rebated wood bead nailed or 'ngs in the wall, as shown in fig. 185. This is also a g the walls are tiled. The method

generally carried out in the case of tiled walls is to turn the safe up against the brickwork, about 2 in., and cover it with the tiles to the floor line. The objection to this is that any liquid on the safe is soaked up between the lead and the tiles by capillary attraction, and thus causes an accumulation of filth which cannot be cleaned out.

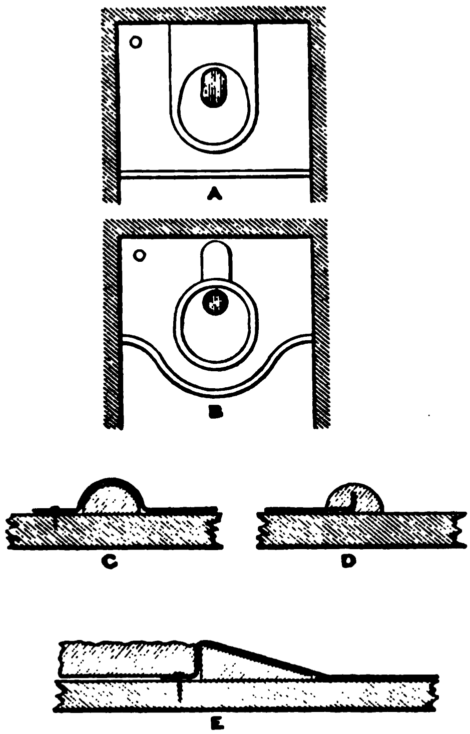


Fig. 186.—Safes under Pedestal Closets

The front of the safe is finished in different ways. Sometimes it is arranged with a straight front, as shown at A, fig. 186. In other cases it is curved in the manner shown at B, and the edge of the lead is dressed over a half-round roll as shown at C, and copper-nailed on the floor. Some prefer to turn the edge of the lead up about ½ in., and cap it with a hardwood roll having a groove in it to receive the edge of the lead as shown at D. E shows another style. The safe should be arranged to fall to the waste-pipe, and this should be fitted with a brass or nickel-plated grating, soldered to the pipe flush with the floor.

Lead safes for baths are arranged in a similar manner to those described for water-closets, whether the bath is enclosed or independent. The sections of the rolls for the outside edges are also the same. These should be parallel to the front edge of the roll of the bath, and concentric to the curves at the head and foot, and should project about 6 in. beyond, so as to leave a good margin to receive the splashings and drippings from the edge of the roll. The splayed fillet shown at E is perhaps more particularly suitable for a bath safe, as it forms a straight square edge to abut against the thick drugget or bath rug which may be placed in front of the bath.